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DEDUCTIONS FROM THE RECORDS OF RUNNING IN THE LAST OLYMPIAD

By Professor A. E. KENNELLY
HARVARD UNIVERSITY

IT is much to be regretted that after all the races held in the ancient days of Greece and Rome, when the laurel crown of victory was the height of ambition in youthful manhood, we have no means of comparing the achievements of their runners with our own. We shall never know how their track speeds compare with those of modern times, because records did not become possible until after the invention and development of the portable chronometer.

The olympiads, or quadrennial athletic meetings of ancient Greece, were held in such national renown, that they served as historical epochs for the chronological establishment of events. Owing, however, to the absence of sufficiently precise instruments for measuring and recording time, each race or speed-contest, although an event of great momentary importance, was necessarily cut off from all comparison with similar preceding or succeeding races. The victor in each race overcame the opponents who contested with him shoulder to shoulder; but there could be no means of determining whether the victor of a given event in one olympiad excelled the victor in other olympiads.

With the introduction of the stop-watch, races ceased to be merely momentary efforts for mastery in speed. To the interest of the local and passing contest was added the new interest of the perennial contest, and of the record. In the racing of the finest horses, the record has come to be regarded as the principal event, and the winning of the race as the secondary event, after the excitement of the occasion has subsided. In the racing of the swiftest men, the record is gaining in importance; but we still attach principal attention to the winning of

the race, as did our predecessors in ante-chronometer days. Medals are given for races won and not for records beaten.

It is, perhaps, our attachment to the interest of the momentary race, and our ordinary indifference to the record, that accounts for the absence of enquiry into the laws of racing speeds. If we ask either an athlete, or a non-athlete who is athletically informed, what is the relation of a runner's speed over a long course to that over a short course, he will immediately reply that a racer over a short course, like 100 meters, runs at a higher speed than over a long course, like 3 kilometers. But if he is pressed for an estimate as to how much faster the racer runs as the course is shortened, he will either be likely to express indifference, or to intimate the opinion that a precise answer is impossible. Nevertheless, it is self-evident that the long list of records which have been established up to this date for runners on courses varying from 20 yards up to more than 600 miles, determine the average speed which the makers of those records severally adopted.

The records reported in the *New York Times* as having been made by the winners of the flat races in the London Olympiad last July are collected in the following table:

Length of Course. Meters	Winner's Actual Time. Seconds	Average Speed over Course Meters per Second	Winners	Time Estimated according to the Logarithmic Straight Line. Secs.	Discrepancy. Seconds	Percentage Discrepancy
100	10.8	9.26	Walker	10.45	−0.35	−3.2
200	22 4	8.93	Kerr	22.8	+0.4	+1.8
400	48.4	8.26	[1]	49.7	+1.3	+2.7
800	112.8	7.09	Sheppard	108.4	−4.4	−3.9
1,500	243.4	6.16	Sheppard	220.0	−23.4	−9.6
42,190	10,518	4.01	Hayes	9,390	−1 128	−10.7

In the accompanying illustration, these records are plotted on a specially ruled paper known to engineers as "logarithm-paper" or "log-paper," in which equal multiples scale equal distances, both vertically and horizontally. The horizontal scale represents course-distances in meters. The vertical scale represents running times in seconds. The stars near the numerals 1, 2, 4, 8, 15 and 420, locate the Olympian records for 100, 200, 400, 800, 1,500 and 42,190 meters, respectively, according to the table already considered. The various circular dots indicate world's records for running, taking the best from professional and amateur lists published in the New York "World" Almanac. The straight line is drawn through the record for 500 yards (457 meters), and also through the record for 7½ miles (12,070 meters).

[1] This contest was reported "no race" in the *New York Times* of July 24. The time, however, is here taken as that of the best preceding trial heat, won by Haswelle.

This straight line offers a simple approximate quantitative relation between record times and distances in races from 100 meters to 50,000 meters.

Considering first the black dots, or world's records, independently of the Olympic records, it will be seen that between 100 and 400 meters most of the records fall slightly below the straight line. This means that within that range the record times are shorter, or the speeds

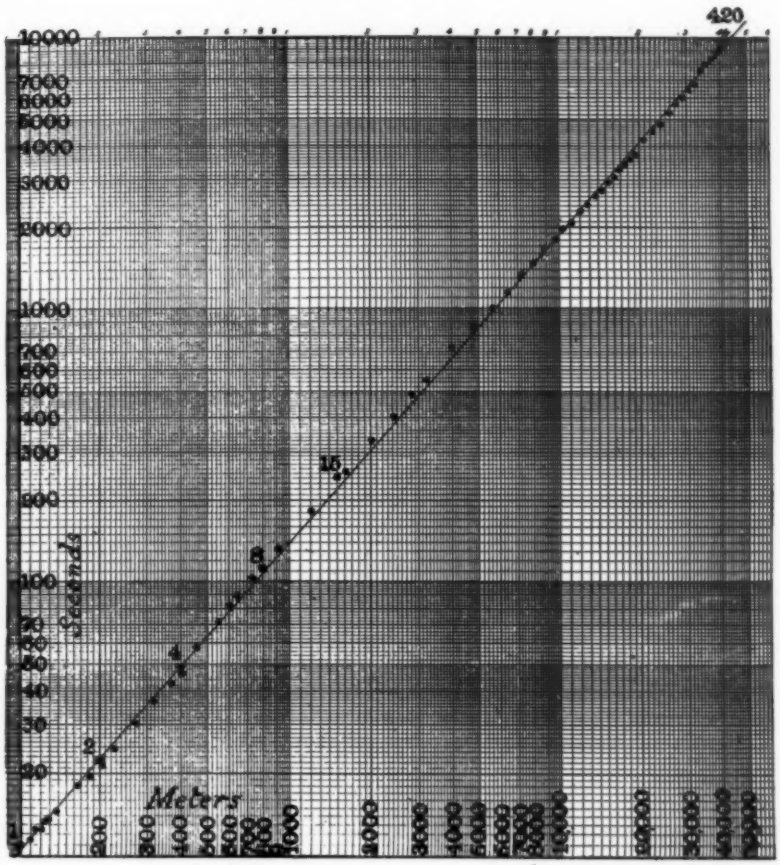

DIAGRAM SHOWING WORLD'S RECORDS AND OLYMPIC RECORDS IN RUNNING RACES.

somewhat higher, than those represented by the line. Then, from 500 to 5,000 meters, the dots fall above the line. That is, the times are longer, or speeds somewhat lower, than those prescribed by the line within this range. From 5,000 to 12,000 meters, the agreement between the dots and the line is close. Between 12,000 meters and 32,000 meters, the dots again fall below the line; while beyond 32,000 meters, they change sides and rise above it.

Turning now to the Olympic records, we may notice that the 200- and 400-meter stars lie close to the line; but slightly above the nearest corresponding world's records. None of the Olympic record stars lie below the corresponding world's records; but the 100- and 800-meter stars lie close to the corresponding dots. The farthest away from the line is the 42,190-meter star. It is to be remembered, however, that the Marathon race is run over country roads, up hill and down dale; whereas all the other races are run on a smooth and level track. This circumstance may account for all, and must at least account for part, of the fact that the Marathon record is 10.7 per cent., or 1,128 seconds, behind the time set by the straight line. As for the smaller discrepancies in the other Olympic records, it is to be remembered that the contestants in Olympic games are amateurs, whereas the world's records are the best that professional as well as amateur champions have been able to secure in all racing annals up to date.

So far as appears on its face, the illustration suggests that the existing world's records offer a better chance of being lowered between 500 and 5,000 meters, than those below 500 meters, or those between 5,000 and 12,000 meters. It is, in fact, generally conceded that races up to the quarter mile (400 meters), inclusive, are the most strenuous, and that races of from half a mile to three miles usually leave the runners in a less completely exhausted condition. If this concession be denied, and we take it for granted that all these records from 100 meters to 50,000 meters call for like strenuousness of sustained effort and degree of physical exhaustion from equally good athletes, it is hard to explain the oscillations of the record dots in groups from one side of the straight line to the other.

The straight line in the illustration stands, however, for much more than a mere indication of possibilities in regard to records. It also involves the conclusion that any record-making runner becomes exhausted very rapidly as his average speed is increased. For example, in the above table of Olympic records, it appears that the athlete Sheppard held an average speed of 7.09 meters-per-second over the 800-meter course; but only 6.16 meters-per-second over the 1,500-meter course. We may safely assume that Sheppard arrived in each case at the winning post, "run out" or practically exhausted in running power; because if he had arrived with any residual running energy, he would have thrown it into acceleration on the last lap. Consequently, when he ran at 6.16 meters-per-second he ran himself out in 243.4 seconds; but when he increased his average speed, to 7.09 meters-per-second, he ran himself out in 112.8 seconds, or in less than half the time. That is, increasing his average speed 15 per cent. exhausted him in 46.3 per cent. of the time. The law of the straight line in the illustration is, in fact, that the time of exhaustion is inversely as the ninth

power of the speed within the limits of racing speeds; so that a record-maker, if he were able to double his speed, would become exhausted 512 times more quickly. Of course, the straight line can only be regarded as an approximation to the actual conditions, and we are not justified in asserting that the law of the inverse ninth power applies strictly. The exhaustion time as the inverse ninth power of the average speed is an average law, derived from the world's records, as made by a number of different individuals at different times. It is, however, certain that whether the time of exhaustion for any particular racer is as the inverse ninth, eighth or other power of his speed, it is a relatively high inverse power. We may safely conclude from the records that a record-making runner can not increase his speed within racing limits without bringing down his time of exhaustion very rapidly. Otherwise, the record times over different lengths of course would surely follow a different series.

It further follows from this deduction that a record-making runner can not afford to run at an unduly high speed for any appreciable time during his race; because, if he were to do so, he would thereby exhaust himself at a yet more unduly great rate. It would seem that in order to make his best time he must keep to a uniform pace, at least to a first approximation. It is evident that on the last lap he will put forth all his remaining effort, and spurt if he can; because he should arrive at the goal run out if he has done his utmost. If, however, he is able to spurt to a marked extent on his last lap, he has held too much energy in reserve, which he consumes unduly rapidly at the higher speed. According to the logic here set forth, he should have been able to reach the goal more quickly by a slight uniform increase in speed over the whole course.

According, then, to the deductions that the straight line of the illustration leads up to, an athlete of record-making quality should be enabled to make his best time over his best course or courses, by being paced at a uniform rate, say with an automobile. This, however, assumes that the runner would exert himself as fully behind an automobile as when running shoulder to shoulder with an antagonist. This is, perhaps, treating an athlete like a mere automaton, instead of like a human being. It seems more reasonable to suppose that an athlete's best performance can only be elicited under the spur and incentive of individual competition. Besides, the interest of a race to the onlookers would probably be greatly diminished if instead of the struggle of a number of racers were substituted the effort of a racer to keep up with a motor.

Nevertheless, the opposite proposition will be likely to meet with general approval; namely, that the worst way to elicit a good performance from a record-making type of runner is to incite him to an unduly high

speed at some part of the course before the end. The average speed of a record-making Olympic runner on a 100-meter course is given in the table as 9.26 meters per second. In the 1,500-meter race, Sheppard averaged, as we have already seen, 6.16 meters-per-second. Suppose that he commenced, say, by running at 9.26 meters-per-second. This would have been only 50 per cent. more than his average speed. It is clear that, had he done so, he would have been run out in 10 seconds. Again, if he had commenced by running at 7.09 meters-per-second, his average speed over the 800-meter course, and not quite 15 per cent. above his average speed over the 1,500-meter course, he would have been run out after 112.8 seconds, or only about half way.

It seems possible, however, to combine the incentive of shoulder-to-shoulder competition with uniform pace-making, and without loss of interest to the spectators, by running a light flag or pennant by the side of the track, on a slender wire of steel or phosphor-bronze. It would only be necessary to set short posts beside the track, each supporting a light metallic guide-pulley. Over all these pulleys would run the wire alongside the track, making a complete loop or endless chain. The wire would be propelled at some point in the course by a small electric motor, driven by a portable storage battery, as in the outfit of an electric automobile. An attendant at the motor would be charged with the duty of keeping the speed of the motor and wire uniform at that corresponding to the record for the particular event. By means of a *stroboscopic fork, i. e.,* a tuning-fork carrying slotted wings on its prongs, through which a rotating target carried by the motor appears to stand still, it is readily possible to keep the speed of such a motor and wire constant to within a small fraction of one per cent.

When the runners were placed and ready to start, a small flag would be gripped on the running wire a few paces behind the men. As this flag reached the starting line, the starter would fire his pistol. Owing to the starting inertia of the men, the flag would gain a few feet at the first, and the runners would get under way with the flag slightly ahead. Since the flag would reach the winning post in record time, it would be the object of the men to outdistance it at that point. According to the reasoning above presented, they should best be able to do this by keeping close to the flag, which would serve as pacemaker. They should certainly be advised thereby if they started off at too high a speed. The spectators would have the advantage of seeing not only the contest of the actual runners; but also a contest with the "ghost" of the best runner that heretofore had made the record of that event his own, as impersonated in the flag running beside the track.

In raising the ghost of the record runner as above, there might be a danger of hurting the race by the runners losing heart if they failed to keep up with the flag. There might also be a danger of the specta-

tors' losing interest if the flag removed all temptation from the runners to jockey for first place, thus tending to sustain monotony at the expense of sport. Whether these dangers are serious could only be determined by actual trial.

It would, of course, be possible to reduce the speed of the flag, by preconcerted arrangement, to a more readily attainable local record, in place of a more ambitious world's record. One per cent. reduction in speed might make a very marked difference in this respect. There can be little doubt that the flag and motor-driven wire would be a useful device in the training of runners for the track at suitably graded speeds.

The same line of reasoning applies to other races. If the world's records in walking, swimming, skating, rowing, horse-running, horse-trotting and horse-pacing be similarly analyzed, and plotted on logarithm paper, the points will be found to fall very nearly upon a straight line in each case.[2] Moreover, all of the straight lines have the same, or at least substantially the same, inclination, or represent and involve substantially the same law of fatigue. The only exception is found in bicycle-riding.

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[2] "An Approximate Law of Fatigue in the Speeds of Racing Animals," by A. E. Kennelly, *Proceedings of the American Academy of Arts and Sciences*, Vol. XLII., No. 15, December, 1906.

MONTE ALBAN AND MITLA AS THE TOURIST SEES THEM

By Professor CHARLES JOSEPH CHAMBERLAIN
THE UNIVERSITY OF CHICAGO

IN April, 1908, while investigating the Mexican cycads in the vicinity of Oaxaca, I took occasion to visit the ancient ruins on Monte Alban and at Mitla. A botanist could hardly be expected to speak with any authority upon archeological matters, but, having taken an excellent camera for photographing the cycads, I could not resist the temptation occasionally to point it at objects of mere human interest. Upon examining the photographs, a friend, who has made some reputation as an archeologist, suggested that an illustrated account, written from the standpoint of an ordinary tourist, would be of interest to the public, while the photographs might be useful to those better acquainted with the general subject.

Oaxaca is easily reached. Starting in the morning from Puebla over the Mexican Southern Railway, there is a pleasant ride of 228 miles through magnificent mountain scenery and prosperous plantations. From Tomellin to Las Sedas, forty miles, there is a grade so

Fig. 1. Some bear Pictorial Inscriptions.

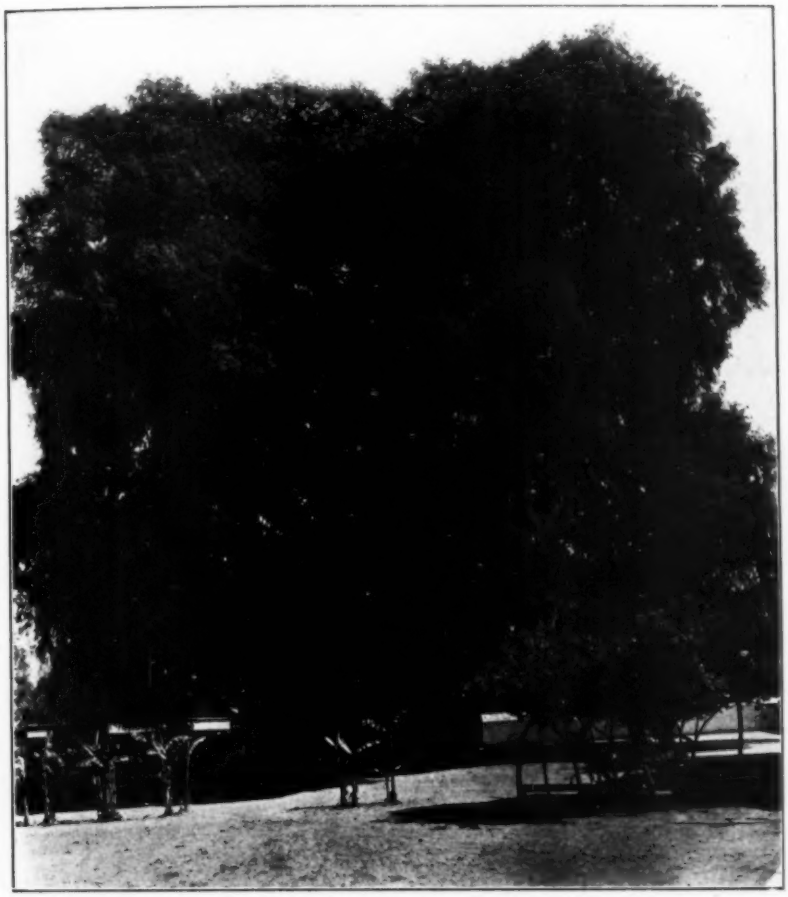

FIG. 2. THE BIG TREE OF TULE.

steep that I was told one could coast all the way from Las Sedas to Tomellin. On the trip back I tried it and found it to be delightfully true. On a small square platform, resting upon two pairs of freight car wheels, the trip was like a long, breezy shoot the chutes, the speed sometimes reaching more than thirty miles an hour. The precipitous cliffs, lofty mountains and deep gorges, together with gigantic cacti, are some of the sights of the Republic.

The station stops of greatest interest are Tehuacan and Tomellin. Tehuacan is beginning to be called the Carlsbad of the New World, for its wonderful mineral waters are producing cures which rival those of some of the famous Mexican shrines. The water certainly has a pleasant taste to recommend it and throughout Mexico one constantly meets people who have been cured of various kinds of kidney, liver and stomach troubles. At Tomellin, the Chinaman, Dick-Kee, who con-

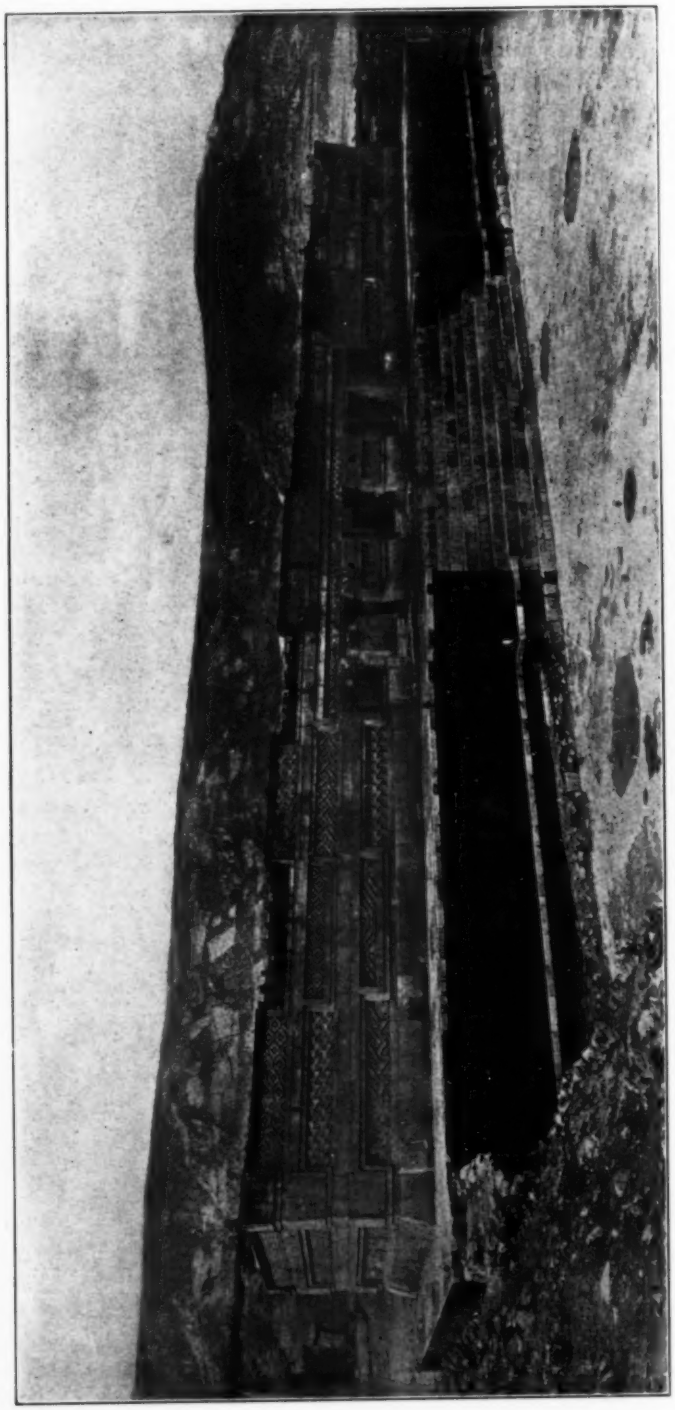

FIG. 3. A BUILDING FACING A LARGE COURT.

ducts the railroad restaurant, makes you wish that you could stop for hours instead of only twenty minutes. On the way back, I had the pleasure of stopping at Tomellin and eating at my leisure, while I watched my less fortunate neighbors trying to eat three kinds of meat, with side dishes, pie, cake and ice cream in the regulation time.

Oaxaca, at an altitude of 5,000 feet, has a climate like a perpetual Indian summer. Already a prosperous town in the time of Columbus, it has grown until it has become an important commercial center, and

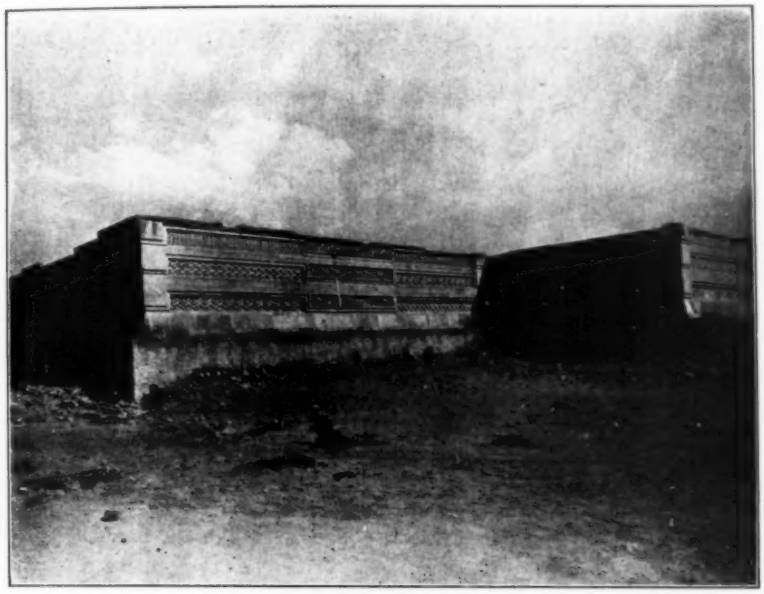

FIG. 4. ONE CAN HARDLY REALIZE THAT HE IS GAZING UPON RUINS.

its numerous cathedrals with their paintings and gorgeous decorations have made it interesting to the artist and architect. The hotels are good and the obliging hosts are always ready to arrange trips to Monte Alban and Mitla.

Monte Alban is said to be about four miles from Oaxaca. It seems farther if you go on foot. The average tourist, even though a bad rider, had better get a horse. When the top is reached, more than a thousand feet above the city, the view of the valley, with Oaxaca spread out like a map, the little villages, rich plantations, and Tule in the distance, is well worth even the climb on foot. The summit of the mountain is covered by the ruin of an ancient city. Whether the individual buildings are temples, stores or palaces, the tourist can doubtless decide with far less hesitation than can the trained archeologist. Some of the stones are large and well cut, some, like Fig. 1, bear pictorial inscriptions, and some have outline images of the entire

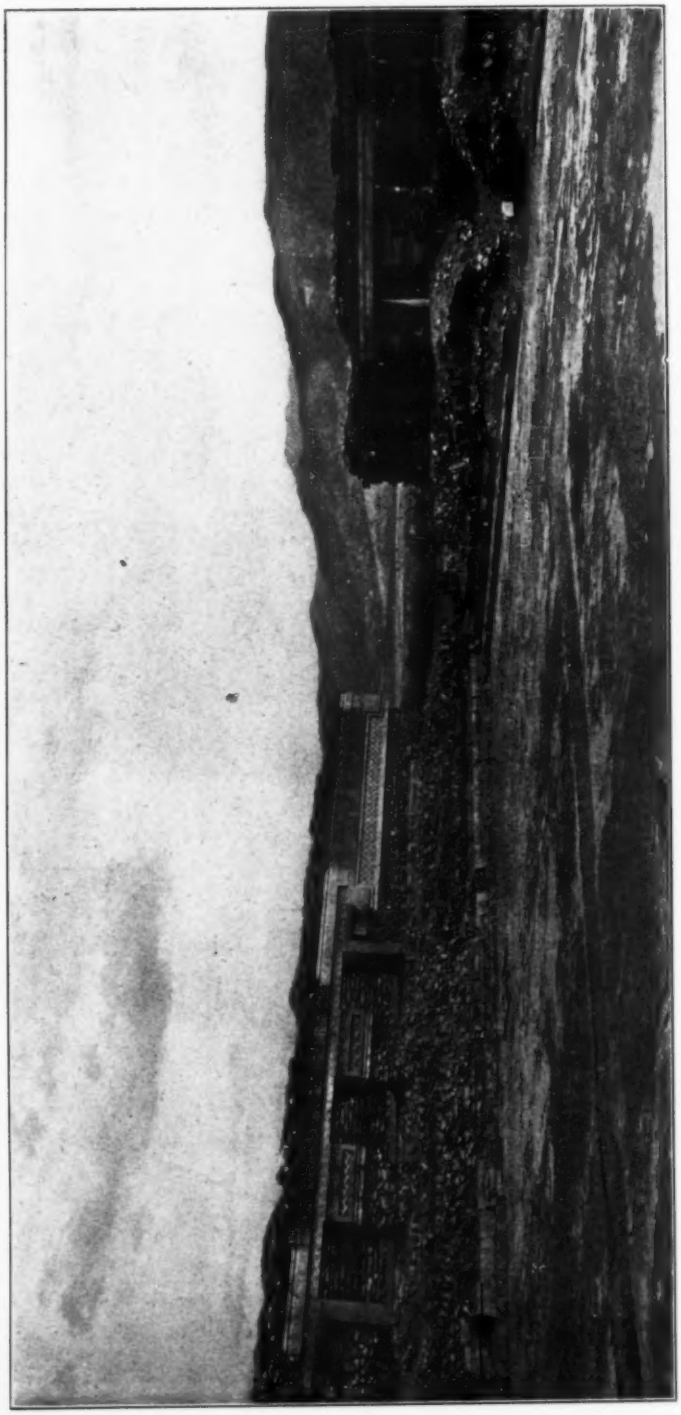

FIG. 5. A COURT WITH BUILDINGS ARRANGED ABOUT IT.

human figure, which to the novice look like Egyptian or Assyrian work. There are pyramids with rude passages leading through them and also chambers, perhaps basements of larger buildings with entrances of primitive construction. There are no arches anywhere. Floors, which in most cases are of a hard cement, resembling modern Portland cement, are still in a good state of preservation. Considering the fact that it is only recently that these ruins have been uncovered, it is not at all improbable that neighboring mountains may also have their ruins of temples and palaces.

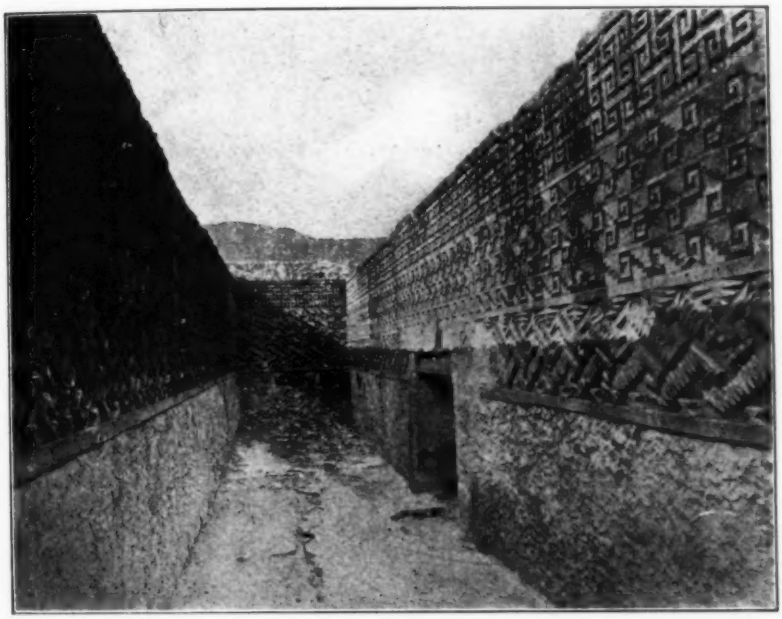

FIG. 6. HALL OF MOSAICS.

There is nothing to eat or drink on Monte Alban; consequently those to whom twelve o'clock brings a restlessness which scenery and ruins can not relieve had better carry a lunch.

A trip to Mitla can be arranged any day. The six-horse coach with four horses abreast in front and two horses in the rear, is the usual means of transportation. Such a coach, which will carry four persons, can be hired for two days for $18 to $25 Mexican money.

About an hour's ride from Oaxaca is the little village of Tule. Even the ordinary tourist must stop here to see the big tree in the churchyard (Fig. 2), but the botanist should leave Oaxaca early by the little tram car and study the tree an hour before the rest of his party arrive. The tree is gigantic, measuring 154 feet in circumference six feet from the ground. This means more than 50 feet in diameter, thus

FIG. 7. HALL OF MONOLITHS.

surpassing the big sequoias of California. The height, however, as may be seen from the picture, is not so great. Botanically, the tree is *Taxodium mucronatum,* and it is commonly called the Montezuma cypress. The *Noche triste* tree in the City of Mexico belongs to the same species. The swamp cypress of our southern states, *Taxodium distichum,* belongs to the same genus, but not to the same species. Without trying to find any fault with the tree, one might hazard the suggestion that it may represent three trees grown together so that nothing but peculiarities in the branching remain to indicate a multiple origin. The Humboldt inscription, placed there by the great explorer, is on the opposite side of the tree from that shown in the picture, but is now almost entirely overgrown. There have evidently been other inscriptions, but they too are overgrown, and a formidable tablet warns the public against defacing the tree, perhaps referring to the vicious American habit of cutting unimportant names in conspicuous places. There are recent tablets, flat on the ground at the base of the tree, with large letters made of the teeth of cattle. If it is all one tree, its age could not be less than three or four thousand years. In the same churchyard there is another Montezuma cypress, twelve feet in diameter, which shows not only in its general habit, but in its branching, that it is a single tree.

The road from Tule to Mitla is sandy and dusty, but the scenery

makes one forget such trifles. The mountains on the right are rocky and are covered with yellow and green lichens. Those on the left have some trees and the valley between is fertile, and the people—as everywhere in Mexico—are happy and contented. Not to be forgotten are a couple of little villages where one can get pineapple cider and lemon ices.

Arriving at Mitla about noon, one is surprised at the comfortable hotel with neat, airy rooms, clean beds and excellent fare. Even a fastidious fault-finder could live there and worry because he could find nothing to criticize.

After luncheon, a five minutes' walk brings us to the ruins. The crude remains on Monte Alban had prepared me for a disappointment at Mitla, but the first view removed any such anticipation. One can hardly realize that he is gazing upon ruins so old that no one knows their age or who built them. The reader will admit that Fig. 4 looks more like the finished work of an up-to-date architect than a ruin. This picture shows the general style of the exterior of all the Mitla ruins. Everywhere there is the same elaborate ornamentation.

The interior side of a building facing a large court is shown in Fig. 3. The stair has been partially restored, but otherwise the description made by Cortez applies equally well to-day. Through the entrances at the head of the stairs one catches glimpses of the rooms

FIG. 8. A WELL-PRESERVED CORNER.

beyond. At present the rooms are not at all roofed over. On each side of the central entrance is a hole in the wall from which an idol has been removed. The court in front of the steps is of a concrete like that found on Monte Alban. Monoliths like the one in the foreground are fairly numerous. Another view of a court with buildings arranged about it is shown in Fig. 5.

The rooms of the buildings surrounding the courts are still very beautiful. Among these, the *Hall of Mosaics* (Fig. 6) seems to be the best preserved. If these long, narrow halls were ever covered by any heavy roof, the ventilation must have been bad, for even in their present open condition they are hot enough on a warm day.

FIG. 9. THE STONES ABOVE THE ENTRANCES ARE VERY LARGE.

Another hall, considerably wider and with a row of six huge monoliths in the center, is called the *Hall of the Monoliths* (Fig. 7). These monoliths, which are about twelve feet high, seem to have supported some kind of a roof, and, judging from their strength, the roof must have been something more than cloth or palm leaves. The walls have no mosaic ornamentation, but seem to have been completely covered by a hard, thin coat of cement or plaster, which was painted a dark red. Just beyond the second monolith one sees in the wall a niche which may have contained an idol.

A well-preserved corner is shown in the following view (Fig. 8). Since the masonry has begun to crack, steel beams have recently been

FIG. 10. DETAILS OF THE MOSAICS.

inserted above these two entrances. The rooms beyond the entrance are narrow and elaborately ornamented with a pattern similar to that in the Hall of Mosaics.

The stones above the entrances are very large. The one shown in Fig. 10 is eighteen feet long. The side of the entrance, against which the children are standing, is also a single stone.

The dark spot on the cement floor, seen through the opening, is the entrance to a series of subterranean chambers. These are low,

FIG. 11. PICTURE WRITING.

dark dungeons, ornamented with the mosaic patterns shown in previous views. A modern steel gate with a big lock keeps out unaccompanied travelers. After we enter, get candles and register our name and address, the guide conducts us from one room to another, sometimes coming up into rooms open above, but which we had not seen before, and then going down again until we get bewildered.

The details of the mosaics are interesting (Fig. 10). As is already seen from the picture, the design is partly cut and partly laid. The pattern projects about two inches and in the lower part is very peculiar in its angles and in the regularity of its irregularity. The entire structure, even the smallest pieces, is of stone, there being no bricks in the construction. Not only the mosaics, but all other parts of the buildings are put together without any mortar or cement. The fitting is extremely accurate and the edges of the stones, in many cases, are as sharp as if recently cut. The stone is like that found everywhere in the neighboring mountains.

Aside from the mosaics, the ornamentation has largely disappeared. The guide informed us that even within his memory there had been large patches of picture writing like that shown in Fig. 11, but that enterprising tourists had chipped off so much of it that the entrances to the chambers had been walled up as in this picture, so that they are now reached only when the steel gate is unlocked by the guide. By looking closely just above the walled portion, one can see the general character of this ornamentation. The groundwork is a hard plaster painted a dark red, while the tracing is in white.

What the buildings were for is a problem which the tourist is more ready to solve than those who are better informed. Perhaps these are the ruins of a great temple. To one tourist, at least, they seem to have been better adapted to the festivities of a great royal court. But whatever they may have been for, they prove that the people who built them were well advanced in art and architecture.

THE ROTATION OF CROPS

By SAMUEL FRASER
GENESEO, N. Y.

THE rotation of crops or the order in which crops are grown upon the same land during a period of years is of such moment to the successful development of our agriculture, and consequently of our national welfare that it must receive consideration. The farm value of our farm products has increased rapidly in the last few years, having risen from $4,717,000,000 in 1899 to $7,412,000,000 in 1907. The figures indicate an increase in value for 1907 of 50 per cent. over 1899. This remarkable growth in the value of farm products is largely due to an increase in the area tilled. Now that the best land is settled, it is essential to increase the productivity of an acre, and as the rotation of crops is one means of securing this result its usage must extend. The use of manure and fertilizers have been recommended and proved to be of value in the eastern states for increasing crop yields. The value of plant breeding and the development of plants which are capable of giving heavier yields and products of better quality has been recognized; and the productions of many workers have added millions of dollars annually to our national welfare. It is safe to say that anything that benefits the farmer and increases his ability to produce wealth is of distinct value to the nation and of direct interest to the world.

A study of the rotation of crops used at any particular period in the history of a nation is of value as a guide to the status of agriculture. Agriculture had its birth in the ages of antiquity, when some mother conceived the idea that she might save herself and her child from famine by growing or affording protection to some of the plants which furnished food. From this time on and for a long time the requirements of the people were scanty, and the crops grown were so few that no rotation could be carried on. Evidence shows that the neolithic people of Europe had the rudiments of agriculture, that they grew cereals, had cattle and were conversant with the arts of weaving, spinning and pottery-making. Among other places, they inhabited the hills of Britain and Ireland, where terraces made by them on the hillsides in Wiltshire and even as far north as the Cheviot Hills and the Grampian Mountains of Scotland are still visible. These races practised irrigation and a system of agriculture something like that now in vogue on the hills of parts of China and among the Coorgs, a hill

IT IS A FOUR COURSE OF (1) CORN, (2) OATS, (3) WHEAT, (4) HAY—TIMOTHY AND CLOVER. First year. Corn, grown for silage. About 10 tons of silage is cut per acre. Corn permits of intertillage and cleaning the land of weeds.

tribe, in India. The inhabitants of Britain were Iberians, a non-Aryan race and related to some of the hill tribes of India. The hills were peopled first because they were free from trees, and the soil was easy to till, while the valleys were swampy, marshy and often covered with timber, which they had no means of removing except by fire. The forests were held to be more or less sacred, even at so late a period as the Roman invasion. The Druid priesthood is held to be of non-Aryan origin, but surviving a conquest, was accepted by the Celts. Two Aryan races, the Celts and the Saxons, invaded Britain, one before and one after the time of the Romans and both learned their agriculture from the race they overcame. At this time the community generally owned the land, and its management was vested in officials elected for the purpose. The Romans introduced individual ownership, and this was never uprooted. It grew gradually under the Saxons and more quickly under the Normans, but made its most rapid progress during the fifteenth and sixteenth centuries, when wool was the valuable product and land was wanted for grazing sheep. During this time the customary method was to cultivate a piece of land for a few years and then, leaving it to go back to grass, break up another piece, and cultivate it until it became unprofitable. It is interesting to note that wherever population is scanty this method is adopted, whether in the ages of antiquity in Europe or during the nineteenth century in America. In some parts of the United Kingdom, modifications of this system existed at a comparatively recent date. The

FIRST YEAR. CORN. Whenever possible part of the crop is grown to furnish corn and the storer (stalks and leaves) are fed to steers and young cattle. The present high price of grain is forcing the farmers to grow more concentrated feeds on their farms.

town of Kells, in Ireland, owns 1,700 acres, which was farmed by the community. About 130 acres were broken up at a time, and were cropped for four years with wheat, beans and fallowed and then seeded to grass and another 130 acres were plowed. Stock was grazed on the untilled land, each citizen having the right to put a certain number of stock on the common. The town of Lauder, in Berwickshire, Scotland, had a similar custom. These examples illustrate some of the methods in use when the Pilgrim Fathers sailed for America, and the rotation of wheat, beans and then a fallow remained the most common in Britain until 150 years ago.

Xenophon speaks of a two years' cropping of wheat and fallow, and Roman writers remarked on the value of growing a leguminous crop before sowing wheat, a fact which remained almost unused until 150 years ago and unexplainable until the close of the last century. Now it is a maxim that at least one leguminous crop shall be grown in a rotation, because such crops have the power of gathering nitrogen from the air in the soil, and their roots and stubble when plowed under enrich the soil in humus to a greater extent than most other crops.

In the early days of this country and in newly-occupied places it was customary to grow one crop, either wheat, corn, tobacco or cotton, as circumstances required, for a number of years upon the same land, until the yield from the crop was reduced to such a point that it became unprofitable. More land was then taken and treated in a similar

SECOND YEAR. GRAIN CROP—OATS. On the Cornell University Farm yields of 50 bushels per acre are often secured.

manner. Such methods are permissible only in a thinly populated country. Some time previous to this some men had noted that in nature the crops grown on a piece of land during a term of years varied, and it is common observation to-day that in the north, hardwood trees, as oaks, will come in where pines have been cut off. Hemlocks do not succeed hemlocks. And even in grass land marked changes occur in the composition of the herbage. During a period of wet years Redtop (*Agrostis vulgaris*) may assume the ascendancy on a piece of land, and lose it just as quickly when an era of dry years occurs. To secure a rotation of crops, it is essential that crops capable of being grown in a district be known and that there be a market for them. Wheat has been and is the pioneer crop of the northwestern parts of this continent. Climatic conditions are important factors in determining the rotation. In Canada, oats, mangels, clover and timothy may be good crops to include, but they would be of little value for the southern states. Cotton, cowpeas and crab grass would be more likely to grow. It was largely lack of knowledge about crops that prevented progress. Clover and turnips were not grown as field crops in England until about 170 years ago, and even about a hundred years ago, Arthur Young said that probably not more than half the farmers and certainly not over two thirds grew clover, although both turnips and clover were recognized as of value in the sixteenth century, and turnips were used as an article of diet at least as early as 1390. About 1730 Lord Townsend introduced on to his barren estate in Norfolk what has

THIRD YEAR. WHEAT. PREPARING LAND FOR WHEAT. The last harrowing is being given. A fine tilth has been obtained as evidenced by the cloud of dust which obscures the horses' feet, the harrow and the man. Certain crops permit the disintegration of the soil particles by tillage.

since become known as the Norfolk four-course rotation, consisting of turnips, barley, clover, wheat, and yet, in spite of the most gratifying results, it took seventy years of demonstration before this system of rotation spread over the county of Norfolk. Dickson, of Edinburgh, Scotland, wrote a treatise on the rotation of crops in 1777 and in 1788 Marshall, of England, stated that a common rotation was: first year, wheat, barley or bigg; second year, oats, beans or pulse; third year, fallow. Although the value of a rotation of crops was known to Camillo Tarello, who urged the adoption of such a system in agriculture in 1566, before the senate of Venice, it was little understood elsewhere. Tarello was far in advance of his time and gave a list of the advantages of a rotation, somewhat similar to those known to-day. Yet his careful experiments remained unknown and little used until similar facts were discovered elsewhere. In Great Britain, previous to the translation of Tarello's article and the issue of other works during the eighteenth century, the subject of rotation was generally passed over by reciting courses which might be good, bad or execrable, as though their arrangement were devoid of principle and had absolutely no relationship with the economical management of a farm. That poverty in an agricultural community might be due to a poor rotation of crops and success due to a good one never occurred to the minds of those who ought to have been interested. The value of carrying live stock to consume part of the crops grown had not been recognized, and

FOURTH YEAR. HAY—TIMOTHY AND CLOVER. In 1903 the grass field was mown twice and yielded 5⅓ tons of hay per acre in two cuttings. In 1904 one field yielded 4½tons per acre, the first cutting.

the truth of the proverb—"No grass, no cattle; no cattle, no manure; no manure, no crops"—had not been appreciated. Townsend's four course considered something more than supplying man with grain, a new point of view arose, and in regard to it Arthur Young said: "The grand article of all husbandry is the keeping great stocks of cattle; for without much cattle, there can not be much manure." Two out of the four crops, clover and turnips, and the straw from the grain crops were used for the live stock, either as food or as bedding and the result was a large supply of manure and increased productivity of the soil. The grain crops were separated either by an intertilled crop, turnips, or by a legume, clover. Substituting corn for turnips we have a rotation of equal value for the northern states.

The introduction of clover and turnips into England as field crops is coincident with the improvement of live stock by Bakewell. From this time on meat was added to the diet of the common people of Britain, in small but increasing quantities. It is worth noting the effect that the call for meat had upon the minds of the thinkers of two divisions of the Teutonic race. The English school—including Bakewell, Coke of Holkham, Booth, Bates and many others—set to work to so improve the conformation of their breeds of live stock that they should be capable of producing a pound of beef, mutton or milk more economically; while the German school, led by von Thaer, began the epoch-making research as to the influence of foods upon their live stock, their efforts being to make the foods produce meat more econom-

LIVESTOCK IS A NECESSITY ON A SELF-SUSTAINING FARM. Frequently the four-course rotation used on the Cornell University Farm could be profitably made into a five-course, by retaining the grass for two years, making hay the first year and pasturing it the second.

ically. Thus the one school improved the animals, but paid less attention to the foods, while the other made the ration the primary consideration. Lancaster County, Pa., has made history both for its productivity and its rotation of crops. The two are inseparably connected. Corn, oats, wheat and clover and timothy are grown in the above mentioned order, and the farmers of this vicinity, realizing the value of manure, have purchased western live stock and corn and with the roughage grown have fattened the stock and made money. The object of a rotation should be to convert sunshine into dollars, in such a manner that the soil used shall be as productive at the end thereof, if not more so, than it was at the beginning.

Wheat or corn growing employs a minimum amount of help for short definite portions of the year. Mixed farming, where live stock is kept, requires the retention of help throughout the year, and in this way it is of social importance, a floating population being a serious menace to a nation.

Where the one crop, as wheat, is grown, there is much more trouble in maintaining the soil in good physical texture. When clover is grown, the stubble and roots plowed under increase the amount of organic matter in the soil, which upon decaying forms humus. Humus aids in developing bacterial activities in the soil, the importance of which is now recognized, although feebly understood. The strong taproots of such plants as clover or alfalfa upon decaying leave air

passages in the soil and subsoil, which are of great value in aeration, and render the soil more habitable for certain useful bacteria and more permeable to moisture and roots of succeeding crops.

Constant tillage of most soils may make the particles so small that they tend to run together in wet weather and bake into a hard mass upon drying. Putting land into grass for a few years permits the aggregation of soil particles and in this way a rotation corrects injuries.

Fields in grass are less expensive to work than the same area under intertilled crops as potatoes, or roots, hence a mixed farm can be managed well on less capital than one entirely under tillage. If grass can not be grown, alfalfa may be. Alfalfa is usually left undisturbed for several years and like other legumes produces marked increases in the succeeding crops. At Rothamsted Experiment Station, England, land which has been growing leguminous crops for fifty years was plowed up in 1898 and sown to wheat for the five following years with the result that the average annual yield per acre for this period was 27 bushels on the alfalfa plat, 24 bushels after white clover, 23 after red clover and sainfoin, 22 after sweet clover and 20 after peas, beans or vetches, while on the plats growing wheat and fallowed on alternate years for the same length of time, the yields averaged 7.5 bushels per acre per annum during the five years under consideration.

Grain crops as commonly grown do not permit of intertillage, hence the land is liable to become weedy. Intertilled crops can not be successively and profitably grown for a series of years unless they are specialties and bring high prices, as truck crops near towns. Under these circumstances special care is taken in manuring and fertilizing and in combatting insects and diseases. Constant intertillage depletes the soil of its organic matter, the trucker puts this back in his manure. At the Cornell University farm, which is run as a dairy farm, the four-course rotation of (1) corn (land manured about 8 to 10 tons per acre) cut for silage, (2) oats, (3) wheat (manured 8 to 10 tons per acre) and (4) clover, 10 pounds, and timothy, 15 pounds of seed (sown in the wheat), mown twice, has been quite valuable in bringing a poor unproductive farm into a high state of productivity. About 10 tons of corn silage is grown per acre, 50 bushels of oats, 30 to 40 bushels of wheat and over 5 tons of hay per acre (two cuttings). The root residues and the manures applied have been sufficient to preserve and augment the humus content of the soil.

Many plant diseases and insect attacks are easy to combat if a good rotation be adopted. These troubles have and will do more to enforce the consideration of a rotation of crops than almost any other factors. During the year 1904 in trials of mangels on the Cornell University farm the value of a rotation of crops was shown. Two plats separated by others had been growing mangels for three years. In 1903 the leaf

spot disease (*Cercospora beticola*) was prevalent. In 1904 the crop was sown on these and on plats which had been in corn in 1903 and other crops previously. The disease attacked the beets on the "no rotation" plats early in the season, and many rows had to be resown. The yield per acre was 9.5 tons containing one ton of dry matter, value $20. The yield per acre on the rotation plats was 33½ tons containing four tons of dry matter, value $80, a clear gain of $60 per acre from the rotation of crops.

Different crops require different amounts of water to make a pound of dry matter, that is, some transpire more than others, thus oats will transpire 500 pounds, potatoes and corn about 300 pounds, barley about 400 and clover frequently over 600 pounds. From this it will be seen that the Maine farmer is wise because he is discounting the season, when he sows oats the year after potatoes in his rotation of clover (two years), potatoes, oats; thus a light water consumer is placed between two heavy consumers. This is important since water is generally the factor which controls the yield of crops. At Rothamsted, England, where wheat has been grown for 60 years on the same piece of land without manure or fertilizer, the average yield per acre is about 12½ bushels, while on land in a rotation—but otherwise similarly treated—the average yield was about 26 bushels. During the last 52 years the total yield of wheat is 665 bushels, which at 75 cents per pushel is worth $498.75. That of continuous barley growing, also without manure or fertilizer, during the same time, was 868 bushels worth $434 at 50 cents a bushel. When wheat and barley were grown in rotation with roots and clover or beans, without manure or fertilizers, the yields and values of the 13 crops of each were roots 9.5 tons, $19; barley 333 bushels, $166.50; clover (5 crops) 4.42 tons, $44.20; beans (8 crops) 104 bushels, $104; wheat, 335 bushels, $251.25; a total of $594.95.

The income from the land under this system is in favor of the rotation. It is $96.20 or 19 per cent. ahead of continuous wheat farming and $150.95 or 34.75 per cent. ahead of continuous barley farming.

Scientists have been kept busy explaining why we should get better yields from a rotation of crops. De Candolle over 100 years ago suggested that plants excreted a poisonous substance which rendered the soil objectionable to others of the same species, a theory which is again coming into some prominence. The continuous culture of wheat and barley at Rothamsted was undertaken partly to test this. Experiments now being conducted at Woburn Fruit Station, England, show that grass injures fruit trees, and it is claimed that the injury seems to be due to some poisonous substance, either direct or due to bacteria. Liebig suggested that plants tended to exhaust the soil by the removal of different ingredients and that as some plants took more of one in-

gredient than others, a rotation tended to strike a balance. The actual amount of plant food removed from the soil by crops is infinitesimal, and usually a good rotation will remove more than single cropping. The losses of valuable ingredients from the soil by wind or washing are of more importance than those lost by the sale of crops.

The practical benefits from a rotation of crops are now recognized to be manifold, including greater ease in maintaining the soil in proper physical condition; greater opportunity for catching and retaining the water which falls upon the soil, and more economical use of it. Insects and diseases are more easily combatted, and increased vigor of the plants results in increased yield. In addition, labor, manures and fertilizers are more economically used with benefit to the farmer, farm and the nation.

THE PUBLIC-SCHOOL TEACHER IN A DEMOCRACY

By HENRY R. LINVILLE
NEW YORK CITY

THE present wide-spread interest in the economic situation of school teachers in America has its sentimental foundation in the recognition of the generally beneficent relation of the public-school system to the people. With the gradual disappearance of ignorance and open cruelty among those who teach, and the establishment of a more perfect organization of the machinery of education, there has grown up intelligent interest and admiration of our school system in our own and in other countries. We, as well as our foreign admirers in educational lines, do not overlook the sad existence of evil conditions in outlying districts, but the energy of money and organization is being directed to the wiping out of these black spots on the map. Except for the occasional spasmodic anger aroused by local policies, there is general satisfaction with our educational system.

And yet, when we observe the great body of personalities, men and women alike, that transmit the learning of the ages to the young, the conviction must slowly dawn upon us that in proportion to their opportunities the teachers of elementary and high schools in this country do not measure up to the requirements of the situation. The ineffectiveness of school teachers in the most important functions of teaching is general, and is tacitly recognized by the thinking public. The exercise of commanding influence by them in any branch of social activity is unexpected, and is almost an unheard-of thing. We do not expect from this body of public servants constantly in touch with social conditions effective leadership, or the suggestion of important constructive ideas. The originators of ideas for the betterment of mankind do not look to school teachers for support, or even for understanding.

However, students of social life in America, know well the wonderful advance in the quality of teachers within the last hundred years. It is known that the schoolmasters of our English and Dutch colonial ancestors were generally social derelicts, failures in everything else, and much given to intoxication. We may safely claim that the advance in knowledge and in respectability in the ranks of those who teach has been greater than the advance of society generally. This hopeful fact might render unnecessary critical studies of the personnel of the

profession of teaching, if it were not that new ideas in education urgently demand a hearing. These new ideas are concerned with the development and perfection of natural tendencies in the individual—which, if properly directed, would bring him into more sympathetic and efficient relation with society. It is the purpose of this article to show that the average teacher of to-day is not an efficient agent in social advancement. There still persist in him low or vague ideals of conduct. His mind is hidebound, and he is indifferent to problems of a social or political nature. He is aggravatingly humble, and forms a willing block in the existing bureaucratic system of school government.

Persons of even moderately delicate sensibilities are certain to be surprised if they come in contact with many teachers or principals in any of our large cities. One must be limited in his acquaintance if he does not know men in high position in school administration in cities, whose brutality is evident in their treatment of persons beneath them in authority, whose manners and speech are so coarse that their companionship in polite circles would be avoided whenever possible, whose selfishness and narrowness are so intense as to account fully under the present system of school government for their advancement beyond their less assertive fellows. Coincident with the lack of refinement characteristic of some teachers in the public schools, there is so general a deficiency of positive, militant and constructive qualities that the profession in its entirety is noticeable for its lack of intellectual alertness, of moral courage and of social and political understanding.

The student of social conditions has no difficulty in assigning to its proper cause the fact that in every part of the country teachers are often treated with disrespect (tempered with occasional fear) by their pupils, and with patronizing indulgence by people generally. In spite of pronouncements by leading public men, and by newspapers on the great and useful work of the public school teacher, the basic conviction persists that the profession of teaching is customarily followed by men who do not possess the force and manly power and the love of wide activity that characterize men who engage, for example, in law or finance. When the profession is entered by forceful young men, the relation is frequently a temporary one to be given up later for "something better."

The average high-school faculty is a heterogeneous composite of training and ability—a few forceful and several weak characters frequently with only normal-school training, a few college-trained men of ability not invited into college work, and more college men who never would be invited. When all are together the quality of the mass is distinctly commonplace, and does not contain the power of self-stimulation. There is among them an undercurrent of feeling that they are

second-rate. This apologetic attitude is directly traceable as a result to an ideal set up by the first universities, and maintained through the centuries with increasing power. The great idea of the colleges and universities has been that learning is the highest aim of education. They have attained their present station as the result of working out that idea.

In the undergraduate and graduate department of every university in this country to-day, those men who are planning to be teachers are definitely scaled by their professors, by their fellows and by themselves on the basis of their ability as scholars. If they show unusual ability they are set down as future college professors; if less ability, they are scheduled as possible college instructors. The slow ones fall into the heap of future high-school teachers, and are treated accordingly. As long as the present academic and social grading of teachers holds the high schools will have to be content with the less intellectual group, except in the occasional instances where the competition for college positions compels some able young men to take up a high-school career. A high-school faculty then is consciously second-rate, and they will continue to have that feeling, and to hold that place until society advances to the plane of broader and more human, and less exclusively scholastic ideals.

Naturally, one would expect the high schools themselves to begin their own reformation, but the ideas for it are coming from elsewhere, and the hearing for them will come in all probability from enlightened minds in other fields of education, or in other lines of endeavor. High-school teachers, it is thought, and they are so informed by their superiors, have enough to do to attend strictly to their teaching. As a class high-school principals and teachers alike do not think in any profound way, for they give no proof of understanding the social and political conditions under which they work as agents in a democracy. They have no clear and adequate conception of the social and political functions of the school. Their lives are circumscribed and restrained by school laws, and often dulled by the insistent effect of hard, nerve-racking work. When the scholastic training is completed in some normal school or college, the subsequent thinking of the average teacher is incident to the occasional reading of methods. A very high percentage of teachers in the largest high schools of this country make no study of methods, and of the science of teaching, beyond what is necessary to pass examinations.

A layman would suppose that in a profession dealing primarily with the training and development of the minds of people one of the best characteristics of a good mind, self-reliance and independence in thinking, ought to be the possession of those who are in a position to

encourage the development of this characteristic in children. It is a fact, however, that teachers even of the highest scholastic training, with extensive opportunities of forming judgments of their own, are unduly impressed by the opinions of persons in authority. With the leaven of intellectual capacity in the body of teachers as it is to-day, there might develop in the profession some general desire to study and understand the social and political conditions of life in this country and elsewhere, and thus to see the problem of how to make the school contribute to human progress—all this might happen if self-reliance and independence of thought were permitted to develop in our military system of school administration. There is probably no school superintendent in the country who would not urge his teachers to read and contribute from their thought to the solution of academic problems. He would welcome independence of thought as long as it is purely academic. But it is a noteworthy fact that in general the opinions of teachers on questions of school administration with local reference are not wanted. If the opinions expressed happen to be in opposition to those held by the "government," the teacher is guilty of "insubordination." Insubordination is anathema pronounced by principals, school superintendents or boards of education against offending teachers with such accompaniments of tyranny that it is small wonder that teachers are most anxious to inquire what their superiors want them to think or want. The writer was once informed by a superintendent of schools of extensive reputation that in his opinion a teacher who complained of the conduct of a superior officer should be punished for so doing, no matter whether the complaint was based on facts or not. Under those circumstances moral courage would seem to approach foolhardiness.

In large communities where the individual teacher is unknown and ignored, and the school government, only, makes representations to the people, the security of the teacher resides in occasional state and municipal laws designed to protect him from the machinations of political parties, and in his ability to keep his mouth shut and support the administration. His advancement to the highest positions depends not on the possession of unusual ability, but on his capacity to "mix" and make fortunate acquaintances among the officially powerful. In one of the largest cities of this country, it is common among men who are ambitious to hold high positions in the local educational system to make it a point to belong to as many dining organizations of educational officials as possible, to attend public installations of principals, leaving their classes to be cared for by the stay-at-homes, and to put officials of influence under lasting obligations to them by promoting subscriptions for the purchase of expensive presents, under the guise

of sincere appreciation. The plan works, partly because of the emotional power of mutual felicitation, and partly because the administration is too busy to search for abler men who do not push themselves into the official horizon. All this is politics of a subtler kind than any the ward politician knew when in the same community he was the brutal power to be feared and flattered by the hopeful teacher.

The law protects the teacher in his position from the party politicians, but it does not protect the public, and the public makes no attempt to protect itself against the imposition of numerous teachers who have failed to "make good." It is practically impossible in certain of the large cities of the country to dismiss a teacher or a principal for incompetency. He can be harassed, but not dismissed. To a considerable extent custom and state or municipal laws insure him (in the case of teachers) an increase of salary as the years are added to his tenure of office.

The law which protects the teacher from unscrupulous interests strengthens and emphasizes the idea that public positions belong to the holders, and not to the public itself. The facts that a poor or low-minded teacher or principal may not only do infinite harm to human character in formation, but that he also *fails to do infinite good,* have not generally been taken into consideration officially in the best organized school administrations. If any one ever should suggest the idea that by the failure of a teacher to do constructive good in his position he thereby forfeited it, he would be set down as a "dreamer." Teachers and principals have been dismissed for open cruelty or viciousness, but not often for poor teaching, unsympathetic nature, low-mindedness, vulgarity, mental stagnation, and probably never solely for failure to contribute something to the moral and social uplift of a little community—the school. So general is the idea yet among teachers that their business is simply to "teach." A superintendent would need to be strong indeed with his community, if he should undertake to dismiss his inefficient teachers. The worst of them have their "influential" friends, and the argument from "bread and butter" is well-nigh invincible. Our conception of the importance of education in the national life must become more clear, and our belief in education more sincere. Perhaps then we shall have advanced to the position that the selfish, incompetent agent of education shall not defeat or hinder the purpose of a great public movement, no matter what his personal needs may be.

The presence of inefficient and ineffective workers in the teaching profession undoubtedly has much to do with the present low salaries of teachers. The kind of work done, and the quality of it on the whole, have not been good enough to enable organized education to compel the payment of better salaries. Whatever complaints we may make

of the dominance of the dollar in American life, the incontestable fact exists that the public that pays out three fourths of its taxes for protection of life and property willingly, pays out one fourth for public education grudgingly. Why? Largely because the people are not seriously impressed with the implied claim that the kind of education they are getting is worth that much. It is altogether likely that continual agitation will result in teachers obtaining sufficient salaries, perhaps even before the ideals of educational practise are modified in accordance with the needs of human life, and before the people insist that the inefficient workers shall not feed at the public crib. In that case the people will be paying for something they do not get. Their protection finally must lie in knowing what they want in education, as they know what they want in food, but paying for it on the basis of the best it can mean to them, instead of on the basis of the supply.

The wide-spread agitation for an increase of the salaries of teachers has emphasized the fact that teachers display more enthusiasm over a possible rise in salary than they do over any other movement looking toward their professional advancement. Of course it is true that nothing is more important than the wherewithal to feed and clothe the body, and keep it in health. But after that is attended to appropriately, the members of a profession supposed to be contributing to human progress might reasonably be expected to have other enthusiasms, such as intellectual, moral and esthetic. One who has witnessed at close hand the fury of a campaign for equal salaries for men and women teachers in the largest educational system in the country ought to have illuminating experience bearing on this point. When both sides to the controversy spend days of time, and much energy and money, employ dishonest or questionable methods to obtain the help of influential citizens or officials, accuse one another of rascality in public meetings—when men and women teachers do these things in the heat of their anxiety for higher salaries, the idealist who strives for the development of intellect, morality and beauty, must stand aside abashed and all but confounded.

Continuous and earnest as the struggle is for higher salaries, great numbers enter the profession every year, if only for a short time. It is probably true that to a large extent men and women alike take up teaching, because its returns in money are more immediate and better, at least at first, than an equal amount of struggling for an economic vantage point would bring in other fields of human activity. Among teachers there is a constant increase in the freedom from such economic competition as is necessary to hold a position once obtained. Even to obtain the position in the first place, the competition consists in a protected endeavor to increase the quality of formal scholastic preparation, rather than in a sharp rivalry of manly or womanly qualities. Competition between persons of good ability in the profession

of teaching is rare. The very scarcity of teachers in all parts of the country indicates that the competition can not be sharp. It is but natural that timid persons, or those doubtful of their powers, should drift into teaching as into a safe harbor. Having once become settled as teachers they tend to grow content and inert.

Almost the sole suggestion now offered for the improvement of the great body of citizens who teach is to increase the pay. The belief seems to be that a better class, of men especially, would enter the profession. To a certain extent the result expected would take place, but it is very doubtful if remuneration for teaching ever could or should be so great as to draw able young men from pursuits whose chief human interest is that they are profitable. There will, in all probability, always be professions in which more money can be obtained than by teaching. When educational systems undertake to compete with the corporations, for example, the educational systems must lose both the contest and the moral standing they should hope to win. The great danger is that higher salaries may add to the inefficient workers who are already in the work for the money, and thus tend to perpetuate a low ideal of service.

The idealist would have a gigantic task before him if he should undertake to substitute directly for the ideal of money the ideal of unselfish public service. The "practical" man would admit that "public service" has a pleasant sound, but "human nature" demands pay for its work. This is sadly true, even while men's thoughts dwell upon the high purpose of education. They remember the pay, while their souls should thrill with the mighty music of a great idea. True education develops power through knowledge, disseminates truth, instills self-reliance into the minds of the young, teaches the common rights of men, breaks the bonds of unreasoned authority and frees the mind of the future citizens of the republic; it gives them strength to withstand adversity, and leads them to love the beautiful, and to discriminate in all things that bear upon the daily joy of living. The practical thing to do is to put aside the fear that "human nature" is going to stand in the way of the best that can come to the race. The inevitable process of evolution will take care of that, and give us a new and finer human nature. Then the question will arise how to put the true, ideal education into practise, and how to obtain the workers to carry out the purpose.

Among the thousands of "settlement" and other kinds of social workers in the cities of this country there is a sympathetic interest and a point of view which if enlisted in public education would be productive of enormous good. Through the medium of the established and natural relation of teacher and pupil, the human purpose of the social worker now so fraught with discouragement and barren in results

would become practical. There is hardly any question that many of the generous spirits who give their lives to the amelioration of social conditions would gladly work through the agency of public education if they could. The school is so dominated now by the idea of formal education, and "what the colleges require" that considerations of the physical and spiritual welfare of people seem merely incidental. Moreover, the administration of school systems is so autocratic, and the officials often so overbearing, insolent and petty, that finer spirits prefer to ally themselves with other movements. The loss to organized democracy of these finer men and women is great, but more serious still is the loss in a supposedly democratic country of the opportunity to encourage the development of democracy by teaching the principles of human right and duty in the schools and practising them in the administration. No amount of knowledge learned as the result of perfect machinery of organization can justify the neglect to develop democracy through our system of public education.

The officials of administration in school systems in cities in America consist usually of a board of education appointed by the mayor of the city and one or more superintendents elected by the board of education. The members of the board of education are business men representing any profession except the teaching profession. Their absolute ignorance of educational ideals is not considered a bar to their usefulness and probably is seldom taken account of at all. The idea is that the board of education represents the citizens, and supervises the financial business of the system, while the superintendent looks after purely professional or technical affairs. But the effects of the acts of both sets of officials can not possibly be kept distinct. Every town and city in the land has its bitter quarrels between the board of education and the supervising officers. Each side is more or less ignorant of the point of view of the other and indifferent to the point of view of the teaching staff. All this is loose administration because there is no unity of purpose and no centralization of responsibility.

Now, there is a very evident centralization of responsibility in the hands of technical experts in our fire departments, boards of health, and frequently in our police departments. What is the reason that intelligent teachers may not hope for promotion to positions of administrative opportunity, if firemen may? Is it not true that citizens generally would prefer an honest and able policeman as chief of police to any able but untrained and hence ignorant citizen?

The assertion is often made that teachers are not practical, that they know nothing about business. Even if that were true, it would be an argument against the average teacher and not against the idea of giving trained citizens the opportunity to direct those affairs they know most about. With the agency for training ready at hand, it

would be strange if we could not develop men with initiative to plan and skill to direct, equal to the combined abilities of those who now control our school systems.

An arrangement by which teachers might advance as they prove by their constructive ideas and their efficiency that they are fitted for something else that the service requires, would be of enormous benefit to the educational movement. The certainty that, for example, the supervisor of manual training in a large city would be a man from anywhere who could show from his published contributions to the thought on his specialty that he was a master in it, as well as a teacher and a man of unquestioned quality and ability—this would encourage the young teacher to develop to the limit of his powers. When a career of study and effort carries a man to a position of great trust and responsibility, the individual has obtained due recognition, and the cause profits by having an efficient servant. When the position is obtained without full proof of fitness, the individual gets what he does not deserve, the administration deceives the public, and insults every fit person in the service.

Assuming that the people will in time care enough for public education to want it administered for the best results obtainable, it ought to be feasible to establish a system which would be effective and not become selfish with age. If systems of taxation can be submitted to the consideration of the electors, systems of education ought also to be within the range of the average intellect. We should scorn to employ a board to do our thinking and acting on the tariff question; it is the privilege of our American manhood to do that ourselves. Why should we be so willing to accept continually the judgment of educational "experts," and thus cut ourselves off from greater proof of our claims to social and political freedom.

There are questions of large import in education that could grow into national issues, and be crystallized into shape by the collective thinking of all the people. It is not inconceivable that some of these might occupy the attention of congress to the exclusion of the usual petty private interests of importunate individuals and communities. Other issues of a purely local nature, state or municipal, would fall for settlement to the sections interested.

There could be a member of the President's Cabinet, a Secretary of Education, who would be presumed to represent the judgment of the majority on national issues in education, and with his department could have clearly defined relations to the state and to the municipal or other local officials. The state and inferior boards of education that touch intimately the privileges of parents, teachers and children should be elected, and subjected to the will of the people through the

principle of initiative and referendum. That development of democratic government would make it impossible for officers of education to command arbitrarily the inauguration of policies about which neither the people nor the teachers had been consulted.

The power of initiative and referendum resting with the people entirely, or in part with the teachers, would not necessarily be a hindrance to the work of the local boards, but it would keep the interest of all alive to the welfare of the schools. It would encourage and demand greater knowledge of educational questions among the people. It would crush for all time the autocratic spirit that rules sullenly in the seats of a democratic institution. The existence of the officious, overbearing and dictatorial superintendent and principal, and the timid, sycophantic teacher would become impossible. Not only must the relation of the boards to the schools be a democratic one, but the school within itself must be organized on the basis of the same idea. Teachers and pupils have rights which the autocratic principal of to-day tramples upon with impunity, and he is upheld by the officials who created him. The safety of the republic demands the abolition of such a tyrannical condition.

A rehabilitation of organized public education along the lines of the open and just recognition of the rights of all concerned, seems a necessary prerequisite to increasing the efficiency and effectiveness of all persons engaged as agents of education. The fair, honest and public-spirited administration of the schools is a necessary preliminary guarantee to the people that public education is a movement for human progress, and for nothing less.

CELIBATE EDUCATION TO-DAY

By E. S.

IN our public schools are half a million teachers, of whom about four hundred thousand are women. Of these latter over half are spinsters or, according to official investigation and correspondence, have taught eight years and upwards. They have crossed the female dead line of matrimony, having reached the age of thirty.

The proportion of "old maids" is even more striking according to the estimate of school officials in some of our larger cities. In San Francisco, Pittsburg, Boston, Philadelphia, Buffalo, Denver, New Orleans, Nashville, Chicago and Cincinnati the figures run from 50 to as high as 80 per cent. with a general average of about 70 per cent.

These pedagogic conditions have grown upon us so gradually that we have not stopped to consider their significance. It is, however, an entirely modern development, really of the last fifty years. Less than half a century ago men formed nearly 40 per cent. of the teachers; they are now hardly 20 per cent. Some of the largest cities show still greater disparity between the sexes. In Boston and St. Louis, each, men are only 10 per cent. of the teachers; in New York and Indianapolis, 9 per cent.; in Cleveland, 7 per cent.; in Philadelphia, 6 per cent.; in Chicago, Detroit and Richmond, 5 per cent.; in Minneapolis, 4 per cent.; in Omaha, 3 per cent.; in New Orleans, 2 per cent., while Youngstown, O., has not even one man in her 188 teachers. Our centers of population are usually the most advanced in any social tendency and the small number of men employed in them may be taken as an indication of the drift of the whole country.

Throughout this paper it is to be remembered that to all general statements there are exceptions, both numerous and brilliant, and further that these theories of what is best to be done rest upon the interpretation that one investigator places on the data of the past, and the phenomena of the present, including testimony in the printed utterances of other workers in the same field.

The era of celibate education is on us and it behooves us to take our bearing to see whether we follow a safe course. For the male, we no longer have any doubt, he has been tried and found wanting. He dominated teaching for centuries as a celibate and now he is nearly displaced. It can not be said that he was superseded, because there were two sexes in the schoolroom as women were constantly engaged

in teaching as far back into the middle ages, certainly to a considerable extent in our colonial period. The proportions now are reversed, women being in the majority instead of men. The work of men was deficient because bachelors can not really know life. Our civilization is based upon the family as a unit and only married persons really know the duties and demands of our social structure. As education is nothing but preparing young people to take their places in the framework of life, only those who know what that life is can adequately guide these tender feet.

We tried to supply what was lacking by introducing woman, and at first her natural tact, her sympathy and her deference to age-long authority made her popular with educational management after the first shock of conservatism had passed by. With the advent of the public school system her numbers increased rapidly, especially when she readily accepted a lower rate of compensation.

As each sex is only half of the sphere, is there anything in the temperament of woman that will enable her to come nearer filling the other half herself than her brother did? Just like him she is handicapped by the impassable limitations of sex, and, as with him, her nature attains its full measure only through matrimony. The most fully developed woman is the mother, next the wife, and least of all is the "old maid." This last is entirely a modern type, scarcely going back a century, and therefore her capacities are untried and unknown. It may be said she discharges a new function among the many always being created by our civilization, and has come to stay. Time can alone decide whether any innovation will survive, whether the apparently temporary will become permanent. But the question of sex is the most constant and prevailing of all in the interests and relations of the race, and the main features are neither of to-day nor of yesterday, but of all time. Some phases of woman's temperament are the product of the evolution of the ages, and are fixed. A reference to one or two of these may throw some light on this problem.

There are unquestionably two considerations that make the chances of women succeeding alone in this path more doubtful than those of men. First, is her mother instinct noticeable even in little girls playing with dolls. She grows to womanhood with the idea of queening it in a home of her own, least of all is it a part of her dream to rear children of other women. It is a frightful wrench to her whole nature to give up these aspirations for which she is not at all responsible as they are an inheritance to her from the millions of generations before.

The demolition of this age-long air castle brings about a change of her nature, more usually the souring of her disposition. It is well known that she suffers from nervous troubles much more than the man teacher and it is not to be wondered at. If we are to put any reliance at

all upon universal attitudes and firmly crystallized expressions, her married sister, her parents and her brothers, even the children in the seats before her, all look on her as a failure in life, and, worst of all, she feels the same in her heart. Such disappointment would acidulate the sweetest spirit. Besides, she is leading an unnatural existence, dealing with children of the same age twenty, thirty or forty years, while the vast bulk of women have the care of one brood only from marriage to death. The constant strain on her temper within the school and without it makes her either querulous and harsh or flabby and indifferent—both states disastrous for discipline.

For the interests of the student, and consequently of all the race, is it a good model to set before maturing minds that the unmarried woman is the best type of all? Still more, is it wise to have examples of mannish women, as so many of them inevitably tend to the paths that men tread, after admitting to themselves that they are practically excluded from the chosen sphere of women, the home? Many of them turn to money making with all the avidity of their brothers. We have seen such exhibitions of greed and contentiousness among the women teachers in two of our largest cities when they have banded together for an increase in their salaries, going to much greater lengths than men would dare to do under such circumstances. The influence of all this will be felt in time upon the characters of the young.

All these weaknesses in the woman teacher have brought themselves to the surface; they are inherent, and therefore incurable by any method of selection or supervision. If we add the fundamental argument that we have derived from the test with men it seems a foregone conclusion that the celibate female teacher will fall just as far short as her celibate brother; she will fail in the schoolroom just as he did.

Failure is the lot of each because each is abnormal. "The normal citizen is a father or mother," thus tersely and truly does the president of the United States express the sentiment. If this is so and it has to be, who can properly guide young persons into that realm except normal men and women as teachers?

Another deduction from this premise is that we must have both sexes instructing the young. The difficulty with the male has been settled, we no longer require him to be unmated. On the other hand, it is almost an unfailing query on the part of appointing officers whether a male applicant is married or not. In numerous instances the preference is unhesitatingly given to the one with the wife.

This solution, however, should be impossible with women. It is abhorrent and disgusting to the average person to think that men should allow their wives to be breadwinners unless for special reasons. Again has Mr. Roosevelt summed up the case when he spoke of men as the home providers and women as the home keepers. This is the result of æons

of evolution and any general breaking down of this line of division between the duties of the two will end disastrously to both. There can be only two causes for a wife to be in charge of a class, either she has stifled all of the instincts of femininity or her husband is incapable of providing for her. The latter is often justifiable because of misfortune or loss of health. But as young persons can not discriminate, the model before them is terrible. They can only see that the husband is incompetent or the wife is unwomanly, miserly and penurious. A horrible ideal it is to set before them that the chief aim of women in life is to make money instead of to make homes! In spite of this spontaneous repugnance there is a tendency to employ married women, due most likely to an unconscious feeling on the part of educational officials that the "old maid" is too abnormal. It is estimated that in San Francisco 5 per cent. of the teachers are married women; in Denver, 4 per cent.; in Philadelphia, 3 per cent.; in Boston, 2 per cent.; in Chicago about 2 per cent.; all a growth of a very few years. This is a tendency that every one who at all considers the relation of the sexes and the course of development must deeply deplore. The "old maid" in the school is an abnormal exemplar but the wife is a thousand times worse. The woman who neglects the highest, holiest—in fact the only—duty of woman is a hideous monstrosity to teach duty to others.

The best type of male teacher has been discovered after long and wide search—the married man. What is the best kind among women, it is still more important to learn, as we have settled down for the present beyond all doubt to coeducation and to having a large majority of women teachers, whether good, bad or indifferent. The general employment of married ones is repulsive and vicious. The single ones beyond thirty are unbalanced. There is left only woman before that age. She is still normal, still cherishing matrimony as woman's work in life evolved for her through long cycles of time by biology, physiology, sociology and the whole environment of existence. Her path has been marked out for her and the laws of her progress along it laid down by powers far above the scope and the strength of the race to alter. So long as she looks forward to the goal of the wedding she retains the feminine temperament. From the time of maturity until she turns aside from the broad road that the most of her sisters follow, she is almost at the high tide of woman's life. It is then her disposition is most sympathetic and her ideals the clearest and strongest. She is then the most vivacious, the most animated, the most energetic and the best fitted for training the young, because the most companionable with the girls and the best example of womanly graciousness. If we can not have the highest type of normal woman, the wife, we must come as near as possible.

If these golden years, however, are to be taken from a woman's life

she ought to be adequately compensated. Salaries now paid should in most cases be increased 50 to 100 per cent. Such a rate in every locality would command the service of the brightest and most attractive women, who are usually the most intelligent and the healthiest. There would thus be a union of the highest qualities of character, intellect and physique. The objection of cost comes to nothing when the sacredest and most important concerns of life are involved. Of course, the women now in the service should be retained unless they would voluntarily take the higher rate for the limited time. The vext question of age can be easily avoided by placing the limit eight years after high school graduation and five or six after collegiate. There would at the same time be a splendid example to the girls as most of these teachers would marry before the term expired or shortly afterwards. The girls would thus be learning something about the highest duty of life, a kind of inspiration that is given nowhere in our schools now except by fitful instances. It must be remembered that there is a more solemn obligation of marriage than ever before if racial suicide is to be stayed. Fashion and the social system are insistent upon small families, and it is only by universal marriage that the native stock will reproduce itself. It does not do so already in some sections, and it is significant that in those places the spinsters flourish. Our highest institutions, the state and the school, should not encourage the increase of old maids, as their multiplication spells death to mankind. Vestal virgins are a luxury that prosaic America can not afford.

As a corollary with the limitation upon the age of women teachers there would need to be a certain number of men, not over one fourth of the total, to serve as permanent directing heads. This ratio of the sexes is entirely in keeping with the teachings of evolution. Two principles of sex relations seem to be established in these cycles of experience: (1) That both boys and girls are almost wholly controlled by the mother up to the age of twelve or fourteen, with the father's influence becoming more pointed after that on the boys and the mother's continuing over the girls; (2) that all pioneering initiative work, executive management, should be by men. With the men as principals and assistant principals in every schoolhouse, with them as directors of special studies and heads of departments in the higher grades, there would be a solid core for the flitting women teachers to group around and get inspiration from.

These men could be employed on a scale suitable for attracting native strength and ability. They would be sure of a life career in this calling after once having proved their fitness. In order that they should be examples for the youth it should be stipulated that when their usefulness ended their connection with the system would also cease. Without any pension or dole of charity they would be a stand-

ing stimulus to the boys that each should look forward to taking care of himself, not depending upon his neighbors or his government.

This plan would cure two difficulties of the present system. First the whole scale of pensions would drop away, as of course there would be no thought of so rewarding the female teacher. Second the disgraceful squabbles that take place periodically between the sexes over the question of equal pay for equal service would offend the ears no longer. Each sex would be hired on the true basis of compensation within its own ranks. That logical fallacy, such a fond subject of dispute, the equality of work of the two, would appear no more. It would be plain and above argument to every one that there is no such thing as men and women doing the same work in the schoolroom or elsewhere, and consequently to speak of equality of the two is absurd. The relation is far higher than that of equality, it is that of indispensability. It is the same as exists between the two halves of a circle or between the center and the circumference.

For some places, although the general rate of compensation would have to be raised higher, the total expense would not be very much greater. There would be no pensions, and instead of appropriating public funds to people who give no service whatever every dollar would get its worth in the devoted labor of both men and women teachers.

The school next to the family trains for life, for conduct, for character. The best method of development is that of example. What better model for these maturing natures than a teacher who is a success? Success for women means marriage. This notion is entwined in our very fibers so that we look upon the "old maid" as a failure in the great female game of life. The man who can not care for his family and for himself, who becomes a burden upon the goodness of his neighbors, is equally considered a failure. It is not a good pattern to set before the youth that the leader, man or woman, who daily instructs them has not succeeded in the great battle of the world. The schools should have the best and, in the long run, success, for the great bulk of mankind, is the proof of the best: competency for the man and marriage for the woman.

THE INADEQUACY OF SPEECH

By Dr. CHAS. W. SUPER
ATHENS, OHIO

ALMOST all the sounds that the human voice is capable of producing are used to express thought, feeling, or will. Many of these sounds are incorporated in articulate speech; but not all. It is to be remarked further that the term "articulate speech" includes many sounds that are not vocal, in fact the large majority are only modifications of vocal utterance. The most peculiar of those occurs in the language of the Hottentots: they employ sounds produced by inspiration or by means of the air in the mouth. These sounds are four in number and have been described as the "interjection of annoyance on the part of the owner when the china falls, the drawing of a cork, the giving of a kiss, and the sound of encouragement to a tired horse." They can be learned only from the natives by direct communication, since it is as impossible to represent them graphically as it is the croaking of a frog or the wail of a hyena. At least one writer maintains that they are the bridge over the gulf between the speech of man and the cries of animals, and are the primeval utterance out of which language was developed. No one tongue employs all the sounds which the human voice is able to produce, or even a majority. The instruction books for English place the number at about forty; but this is far from being all that are in use. Some languages, like the classical Italian and especially the Finnish, in both of which the vowels are numerous compared with the consonants, have few sounds and such as are easy of utterance. Conversely, the Russian employs combinations of consonants that it is almost impossible for adult foreigners to produce.

It must be remembered that a literary language is an artificial creation. Even the best instructed people do not speak as they write. The national adjective by which a language is designated is a much misunderstood word. England is a comparatively small country, yet to the ear there is much diversity in English speech. This diversity grows slowly less and less with the advance of national education, since by this means each rising generation is gradually led to conform to a common type. Appleton Morgan, the president of the New York Shakespeare Society, affirms that the members of Queen Elizabeth's parliament could not understand one another. This statement does not mean that the dialects of the different counties were as diverse as if they had been foreign tongues, but only that the diversities were of such a nature

as to make complete reciprocal comprehension impossible. At this day the speech of the outlying districts differs to a greater or less extent from that of the capital. We may see, or rather we may hear, the same thing in France and Spain. Although Italy, until recently, had no political capital, Florence has for more than six centuries been the fountain-head of pure Italian, for the reason that the coryphæi of Italian literature were natives of the Florentine district. Much of the so-called Italian used by the uneducated bears hardly more resemblance to the literary type than another language. The same is true of Germany. What is regarded as the best German is spoken near the middle of the present empire, and to it foreigners usually try to conform. The Germans themselves are rather careless about the matter and are content to speak a tongue more or less marked by local words and by a distinctive pronunciation. The speech of Holstein, on the one hand, and that of South Germany and Switzerland, on the other, differs so widely that the natives of these regions who know only their mother dialect are unable to understand one another. I read somewhere that when Schiller first declaimed his early dramas before a middle German audience he was only half understood and that their merit was not appreciated until they were read aloud in a pronunciation unmarred by Swabian, the only kind of German he knew. Even so small a country as Denmark is not without its local peculiarities of speech. In the United States the diversities of speech are so slight as to occasion no inconvenience to a person passing from one end of the country to the other. The reason is that the Atlantic seaboard, roughly speaking, provided the norm for all the region extending westward to the Pacific. The Mississippi valley and the Far West are simply a linguistic extension of the East. The origin of dialects within a given language can only be accounted for hypothetically. They seem to be due to phonetic laws that operated on a larger scale in producing the wider divergencies of speech which are called languages. Limiting the statement to the Aryan stock, it is assumed by philologists that its eight branches are all descendants from one primitive tongue which was at first spoken by a comparatively small tribe. In the course of time the initial group scattered or was dispersed and each fragment became the nucleus of a new language. It needs but a superficial study of all the languages of Europe to make it evident that except the Finnish, the Magyar and the Turkish, together with a few smaller groups, they have many points of resemblance. When, however, we examine the structure of the three just named, we soon find a fundamental difference which is, however, common to the trio. The farther back we trace these eight languages, the closer becomes the resemblance. That the Irish branch of the Keltic differs more widely from the Russian than does the German is owing to the fact that the early settlers of Erin split off from the parent stock at a period prior to those of central and northern

Europe. This is the usual assumption, but it must always remain a hypothesis like so many other explanations of prehistoric phenomena. That English resembles the Scandinavian languages more than it does the German will not surprise any one who takes account of the early history of Great Britain. But who will tell us what brought about the transformation of the prepositive article, as we find it in English and German into a suffix which is its normal position in the Danish-Norwegian and Swedish, a transposition that seems to have taken place less than a millennium ago?

It is probable then that the same psychic cause led to the formation of dialects that in remoter ages produced separate languages. We know that the primitive Germans were a migratory people. At one time and another they are heard from in almost every part of Europe except Russia, because their movements were always southward or westward. When they were constrained to adopt a more fixed mode of life, there was but little intercourse between the different tribes; the divergences of speech, therefore, that had doubtless already begun to manifest themselves, became more and more marked until the introduction of letters among them virtually put an end to the distintegration. We find a similar phenomenon in South Africa. That continent from the equator to the Cape is occupied by the Bantus, except a few enclaves, whose dialects have a clearly marked relationship. No philologist ventures to affirm where the starting-point is to be found, although the general movement seems to have been from north to south. It is remarkable with what tenacity the natives of any particular district cling to the vernacular which they have received by inheritance. The student of the oldest German is constantly surprised by many words, and especially by a pronunciation still in use in southwest Germany, a region in which the language was first reduced to writing, that have undergone but little change in six or seven centuries. We find the same thing in other countries and in England. The unlettered still use words that are only found in the dialect dictionaries; and, as these are a modern innovation, they must have been transmitted orally through many generations. It is more than probable that of the words in common use to-day not a few are pronounced as they were in Shakespeare's time, or even in Chaucer's. There is a considerable number in the former writer with which he evidently makes puns and rhymes, but which lose their point if we give to them the pronunciation now assigned to them by our dictionaries. Evidently *beat* and *bait* were pronounced alike; so were *louse* and *luce, Moor* and *more, wode* and *wood,* and so on. I remember hearing in my youth in Pennsylvania some of my father's neighbors say "yarbs" for herbs, "coo" for cow, but by a singular perversity "cowcumber" for cucumber, "afeard," "pore" (poor), "sturk," together with several other archaisms. As the people who talked in this way were very

illiterate and did not know whence their ancestors came, they can only have inherited, by oral tradition, the words brought generations before by immigrants from the mother country. It is strange with what tenacity the best-instructed persons are wont to cling to the past in matters of speech. When they can not do so in pronunciation, they show their fidelity to the same instinct in orthography.[1] They would greet with a guffaw the suggestion that they should travel, or live, or dress as did their grandfathers, or even their fathers; but they adhere to the spelling of the tenth preceding generation with a tenacity worthy of a nobler cause. In France no less than in England the spelling reformers have an almost insurmountable task before them. It is worthy of remark, however, that many words are pronounced by Americans more nearly as printed than by Englishmen. One seldom knows how to pronounce an English proper name from the printed page.

The primitive races exhibit a lack of capacity for abstract thought that is well nigh incredible. It seems almost impossible for them to generalize. Every perceived object has a separate name because it is a separate entity. Among the Innuits an older brother, a younger brother, a youngest brother, is each designated by a different term. The same is true of sisters; and when a brother, a sister or a father is deceased, still another word is employed when speaking of them. The Lapps have a word to designate the relationship of the husband of a man's sister, and another to designate that of men who have married sisters, but their language lacks one for brother-in-law. In this respect these and other languages are more definite than the English or the German. The Greek and Latin are still more careless in the designation of relationship by marriage. Herein all the primitive races have

[1] The following bits of verse, which I found somewhere, facetiously but truthfully represent some of the vagaries of our English pronunciation and orthography:

My wife had a dog yclept Cæsar,
As a gift he was given to please her.
One day he attempted to seize her,
Angry, perhaps, or to tease her.
She said: "I'd be glad if some bees or
Wasps would do him to death, or a freeze, for
I've no more int'rest in him."

Wife, make me some dumplings of dough,
They're better than meat for my cough;
Pray, let them be boiled till hot through,
But not till they're heavy or tough.
Now I must be off to the plough,
And the boys, when they've all had enough
Must keep the flies off with a bough
While the black mare drinks at the trough.

a well-supplied vocabulary. The range of their observations being limited, the natural tendency to loquacity manifests itself by multiplying words for the same or nearly the same object. It is not an uncommon thing to find persons even in civilized countries whose words are numerous in an inverse ratio to their thoughts. It is very much easier to talk than to think. The language-making faculty produces such a luxuriant crop of words that where the range of percepts is circumscribed it invents a new word for every possible relation in which they may be perceived. If the conditions of the primitive races were changed they would probably find their vocabulary sadly deficient. Under such circumstances it is likely that they would invent a new stock of words, using the material on hand as a basis as far as it would reach. Such we may suppose to be the case of the Eskimo and the Kafirs, if they were to exchange habitats. On the other hand, it needs to be said that this proceeding is not carried very far, but new objects are named by words used to designate them by the people that serve as intermediaries. We accordingly find among the Eskimo of the northwest a number of terms borrowed from the Russians, and, among the native tribes of Africa, words appropriated from the Arabic, the Portuguese and the English, always trimmed to fit the native vocal organs; for it must be remembered that they are learned by adults and not by children, whose vocal organs are sufficiently plastic to reproduce any sound accurately. The process may be seen among the Vai, a dialect of the Mande spoken to some extent in the republic of Liberia: lamp becomes "dampo," bowl "bowli" or "bowri," fork "furokia," hundred "hondoro," coat "coti," pillow "puro" or "puro," trunk "torungu."

When a language has reached a stereotyped stage and the people speaking it continue to advance in thought, there is nothing left for them to do except to discard it for another. This happened with the Hebrew. The library of the British Museum is said to contain ten thousand modern books in this language, among them most of Shakespeare's plays and even Goethe's Faust. It is hard to see how these versions can be more than a mere adumbration of the originals. It is simply impossible to express the subtle thoughts of these works in the rigid ancient tongue. The Jews themselves recognized this. When they undertook to discuss philosophical and metaphysical themes they had recourse to the Greek even when they wrote for their own countrymen. This language of unlimited resources and perfect adaptability to the expression of the minutest shades of thought had been so fully developed and had a vocabulary ready-made for abstract discussion that all who aspired to wide culture betook themselves to it. The New Testament furnishes evidence within the reach of every one. The Emperor Marcus Aurelius, although a Roman of the Romans, felt that

Greek was better adapted to give utterance to the inmost thought of his soul than his native Latin. It is doubtful whether an adequate English translation of his "Meditations" exists as yet. The late Carl Schurz, who was "master" of two languages in a widely different sense from that usually given to this much-abused word, was wont to say that for certain subjects he preferred the English and for others the German. In his mind each possessed excellencies which the other lacked.

Until recently almost all students of human speech accepted the theory that abstract ideas or concepts are its ultimate elements. It was held that the mind itself supplies an inherent basis of knowledge in all our cognitions. A name is a mere empty sign, a meaningless symbol, unless there be a preceding mental image of the object which it represents, or an abstract conception in the mind of which it is the sign. The mental image must precede the name, the abstract conception must be anterior to the sign, if it is to be understood. Ideas must precede the visible or audible or tactile signs. A child knows a great many things before it can speak the name. This being the case, the moon is the "measurer," the sun the "light-giver," from roots meaning *to measure* and *to shine*. Fifty years ago, Professor Max Müller worked out this theory with much detail and popularized it with a profusion of poetic imagery. At the present day, however, it is no longer taken seriously by the most competent judges. Most persons conversant with the facts admit that in nearly all languages there are roots that seem to express purely abstract ideas; but whether these are the oldest elements is another question. Dogs and other brutes know the names of objects as well as their uses although they never learn to speak the former. A careful study of the radical elements of many languages has led some philologists to maintain that the earliest words were a sort of cross between a name in action and an appended demonstrative. *To walk* or *to eat* would thus mean "walker-that-one," or "walker-he"; "eater-this-one," or "eater-he." In some of the languages spoken by tribes at the foot of the economic ladder words are used in a sense utterly foreign to our modes of thought. In the Innuit, for example, "he is my son" really means *he sons me;* "thou art my son" is *I son thee;* "he sons me" is equivalent to *I am his son.* We find a trace of this mode of thought in English owing to the lack of characteristic suffixes, as when Shakespeare says: "Cowards father cowards." Familiar examples of this dual nature of words are boycott, out-Herod, water, table, "move on," "get a move on you"; and many more.

The endeavor to give utterance to internal speech, as we may call it, has called into existence an astonishing number of word-forms to express number, person, gender and case. These various relations are indicated by prefixes, suffixes and infixes, or by separate words. In English the plural is, for the most part, formed by the addition of

an s to the singular. This method is so simple that it could not be made more so. The exceptions are such plurals as oxen, mice, men, and a few others. On the other hand, the Hausa, a dialect of the Mande spoken in central Africa, employs at least seven different ways of forming the plural regularly either by the addition of another syllable or by reduplicating the final syllable with a euphonic change. The Latin has five forms for the plural. In the language of the Bullum and Temme the plural is made by means of various prefixes, *kil* "a house" becoming *tikil, pokan,* "a man" becoming *apokan,* and so on. On the other hand, in the Japanese the plural, in a majority of substantives, does not differ from the singular. Sometimes, however, it is formed by repetition of the singular, or by the addition of another word; but the latter process usually means something more than a mere plural. In the French a large number of plurals do not differ from the singular except to the eye. In the Italian the modification of the terminal syllable often adds a qualification to the root: it may indicate mere bigness, or bigness and ugliness, or bigness and fatness, or bigness and vigor. Conversely, it possesses likewise several modifying syllables to indicate the opposite qualities, as little and neat, little and lovely, or little and unimportant, or little and contemptible. The Finnish is provided with fifteen cases with which to express the various relations in which a noun may be used. Doubling this number for the plural, a Finnish substantive may appear in thirty different forms. Comparing this method with such languages as the French and the Spanish, in which case-relations are expressed by means of propositions, it looks like the extreme of complexity, or like an effort on the part of the Finnish people to resort to an intricate method for doing that which might be done just as well by a much simpler process. Again, if we compare an English verb with the same part of speech in Sanscrit or Greek we find a similar remarkable diversity. A Greek verb with its participles may take more than five hundred different forms to express person, number, tense and case. It must be evident that with such an astonishing variety of resources at command it can express shades of meaning in a single word quite impossible with a Germanic verb. The Semitic languages are, for the most part, very simple in the structure of the verb, having, like the English, only two tense-forms. On the other hand, they complicate matters by giving to the second person, both singular and plural, a form to agree with the sex of the person addressed. Although they lack a passive voice they indicate the passive state by the use of prefixes and vowels placed before or within the radical consonants. The inadequacy of even the most highly developed language to express abstract ideas with accuracy is strikingly shown by a study of the writings of a thinker like Plato. He had virtually no predecessors in the realm of thought in which his mind often moved. He had, therefore, to coin new words, out of pre-

existing materials, or to give to current words a new meaning. He usually chose the latter, thus laying himself liable to be misunderstood at every turn. His followers were, therefore, in the position of the shorter animals that try to feed on branches as far from the ground as the giraffe does. The result is that although his works have been studied and commented upon for more than twenty centuries, we are still told by some of his enthusiastic devotees, that the master is not fully understood. There is probably a good deal of truth in the assertion, for the reason that our psychic experiences are not only conditioned by our environment, but also by our mental structure. As the former can not be reproduced and as minds of like caliber are a prodigy we probably do not fully comprehend what the ancient thinker meant in not a few passages. The truth of this statement may be made evident by a simple illustration. We hear a certain individual say: "I am happy." Upon inquiry we find that his state of mind is the result of his having plenty of food and drink of a kind exactly suited to his tastes and that he cares for nothing else. Another person uses the same expression whose highest ambition is to possess the means to shine in society, but who is relatively indifferent to food and drink. A third person is a North American Indian, who has after long watching and waiting got into his power a mortal enemy whom he can now torture to his heart's content. With these let us now compare the ecstatic feelings of a Copernicus when after long years of study and reflection he had at last become fully convinced of the truth of the heliocentric system. Although all four have employed exactly the same sentence their meaning was wide, very wide apart. But even in less profound matters we can not fully understand a language unless we are thoroughly familiar with the conditions where it has been developed. In some of its aspects German is German the world over. But what different feelings come into our minds when we take up Schiller's "Tell" in north Germany, or in a foreign land, or among the scenes where the drama is laid! The Platt-Deutsch of the northern plains seems strangely out of place in the mountain region of the south. The converse is equally true. And what a feeble imitation of the real thing is the colloquial German of the United States or the French of Canada! The ancients were aware of this. Herodotus tells us that when the messenger of Cambyses came to Psammeticus, the dethroned king of Egypt, to ask him why he did not shed a tear nor utter a cry when he saw his daughter brought to shame and his son on his way to death, but gave those marks of honor to a beggar, replied: "O son of Cyrus, my own misfortunes were too great for tears," and by inference, too great for words. Similarly Malcolm says "Give sorrow words: the grief that doth not speak, Whispers to the o'erfraught heart and bids it break." And again: "Grief that is expressed in words Is slight indeed." Byron also speaks of the "suffocating sense of woe." When

we read an author like Voltaire we feel that in his hundred volumes he said about all he had to say. He puts his thoughts before us lucidly and vigorously, but not profoundly. In the case of Goethe, on the other hand, who could think both scientifically and poetically, we often realize that in spite of the enormous extent of his works his language is not infrequently an indication of his thoughts rather than the expression of the thoughts themselves. The existence of Dante Societies, and Shakespeare Societies, and Goethe Societies has its justification in the conviction that the thoughts of these master minds can be fully understood only by the cooperation of many of inferior caliber. By thus combining and comparing the individual and partial views of a number of separate intellects, they may gain at least an approximately adequate grasp of the psyche of these prodigies.

Perhaps the most remarkable phenomenon exhibited by all the languages of the world is a process we can hardly call by any other name than deterioration. Take, for example, the Greek. Many of its oldest words are both longer and more sonorous than the later ones. But often even the earliest form shows evidence of weakening, abrasion and contraction. At least one consonant was lost in the period lying between the prehistoric and the historic. In many words two syllables are drawn together into one, or a shorter takes the place of a longer word. Sometimes the longer form existed for a time alongside the shorter, eventually to displace it entirely. Often the attenuated vowel e takes the place of the more sonorous a. It would almost seem as if when a word of two or more syllables having a traditional signification had for a time been in use it dawned upon the primitive mind that it could be shortened without losing its meaning. In Greek and Latin this process is not carried very far, but in French all the words derived from the latter language consist only of that portion that precedes and includes the accented syllable. We know that when an uneducated person tries to reproduce the pronunciation of a long foreign word or one that is foreign to him, he usually gets only a part of it and that part often incorrectly: education becomes "edication," sitting "sit'n," somewhat "sumet," the other "t'other," and so on with innumerable examples. This is the every-day process. But where and when shall we place the era of upbuilding? When were the fuller forms in use? The procedure that falls within our ken furnishes us with no answer to the question, not so much as an approximation thereto. Even those languages of which the study began only a generation or two ago exhibit the same phenomenon. The Bantu, the most widely disseminated speech of South Africa, presents many instances where two or more syllables are contracted into one, and where former syllables have left but a single letter as evidence of their one-time existence. As soon as a language is reduced to writing, or becomes a matter of study, and the rising generation is taught to pattern after its predecessors, the

process of deterioration virtually comes to an end, unless only a small portion of those who use it fall under the influence of culture. In such a case the breach between the educated and the uneducated becomes wider and wider. This gradual divergence can be traced both in the Greek and in the Latin. A few persons continued to write the classic tongues as nearly as they could; but they eventually became unintelligible to the great mass of the people. Although Dante had a ready use of the Latin and wrote much in that language, he nevertheless composed a treatise to prove the superiority of the mother-tongue; and he felt that in this alone could he give utterance to the inmost thoughts of his soul.

It is remarkable that the course of what we are wont to call civilization is in a great measure parallel with that of language. During the Mycenæan age in Greece the arts flourished to a degree that seemed almost godlike to Homer's contemporaries. The historic era in Egypt and Mesopotamia, the beginning of which is placed about three thousand years B.C., is one of decline. The same is true of Mexico and Central America. Here not only the age of growth, but also that of decay, has been swept into the bottomless pit of oblivion. We see much and know nothing.

That thought embraces more than speech may often be inferred from a study of public speakers. When persons who are in the habit of thinking rather than talking endeavor to express themselves in public they are frequently at a loss. They hesitate, repeat, often use the wrong word, and are ill at ease for the reason that the vocabulary which they have at immediate command does not offer the exact terms they need. This is particularly true of mathematicians, who are proverbially poor speakers. Take another example similar in kind. I am translating from a foreign tongue into my own. I come across a word for which an equivalent does not at once occur to me. My memory brings into consciousness several synonyms, but all are rejected by my judgment as inadequate. My memory may be compared to a plane surface on which my judgment moves about like a flash-light until it discovers what I am looking for. Or I may come across a foreign word that has no English equivalent. I must therefore transfer it bodily or use an approximation. In such cases the dictionary rarely affords any aid. It furnishes me, perhaps, with a number of more or less equivalents, but it does not help me to select the particular word I am in search of. Again, assuming that Leibniz discovered the Differential Calculus, did he do so with the German, the French or the Latin language? Although we are not justified in assuming that the discovery could have been made by a dumb person, it lies within a sphere of thought where words count for little. There is abundant evidence to prove that many of the subanimals carry on elementary trains of reasoning which lead them to conform their actions to new

conditions. They depart from their usual routine. In the child, thought and speech are developed, *pari passu,* but after a while the latter is no longer indispensable. They need a support just as they do in learning to walk. That thought and reason are not identical may thus be judged in its lowest forms by the conduct of certain animals and from the lowest races such as the Fuegians and Bushmen, since the reasoning powers of the latter always remain at the puerile stage, but also from those persons who have risen into an intellectual region where words are inadequate to express their ideas.

The generally accepted explanation of this tendency to abbreviate words spoken of before is that it is due to laziness, or a well-nigh irresistible impulse to follow the law of least effort. It is, however, more probably owing to the incapacity of adults to apprehend sounds correctly. Even with the utmost care on the part of the teacher and the learner, persons who have reached the age of maturity seldom succeed in acquiring the correct pronunciation of a foreign language. One may continue to add a reading knowledge of languages to one's repertoire as long as his mental faculties are unimpaired, but the capacity to imitate a correct pronunciation seldom continues beyond the age of about twenty. What is done by the child without thought and without effort is impossible to the "grown-ups."[2]

That the psychic life of man can not be fully expressed by language is further evinced by the predisposition manifested everywhere and at all times by mankind to come to its aid with the hands. Hence we have the plastic and pictorial arts together with music. The artistic instinct is nowhere wholly lacking; prehistoric man made rude carvings. A mere daub or a coarse wood-cut gives the beholder a clearer conception of an object than pages of description. The same may be said of a piece of statuary. Words set to music and rhythm in a simple air are more impressive than a mere recitation. When then it is supported by a musical instrument, or better still by an orchestra, the effect is greatly heightened. Even without words emotion can be forcibly expressed by instruments alone or by gestures alone. The orator Cicero is reputed to have said that the actor Roscius could portray the feelings more accurately in pantomime than he was himself able to describe them with words. The instinct or impulse that leads men to endeavor to give utterance to their feeling by rhythm and tones, often very unmusical to a cultivated taste, is almost as old as the

[2] A curious and amusing instance once occurred in my own experience. I was talking with an Englishman who dealt with the h-sound after the somewhat usual manner of his countrymen. Upon my alluding to his weakness in a jocular way, he became very angry, declaring that I had taken up a false charge. Yet in the very words of his defense he committed the peccadilloes against which he was defending his countrymen. On the other hand, I have known several Englishmen who admitted the bad habit and strove assiduously to avoid it.

race. Before the dawn of history there seems to have been in vogue the war-song, the dance-tune, the epic recitative, the religious chant, all accompanied by appropriate gesture and frequently by such instruments as the age could produce. The Orphic legends bear witness to the real or imagined power of the musical art. When in its infancy, it was usually accompanied by gesture and pantomime. We all can bear witness to the tendency of emotional individuals to fall instinctively into gesticulaton in order to emphasize their words. Popular audiences are so much more influenced by their feelings than by their judgment that they are often "carried away" by the commonplaces of a skillful elocutionist, but remain unmoved by the most profound wisdom of the statuesque orator. How contagious emotionalism is likely to be is strikingly shown by the anecdote Franklin tells about the effect of Whitefield's oratory upon his purse.

How jejune must be the psychic life of those peoples that are without any of these arts becomes evident after a moment's reflection. Even if their languages were far better adapted to the expression of thought than most of them are, their soul life would nevertheless be lacking in some of the most effective modes of utterance. It was doubtless this thought that Tennyson had in mind when he wrote:

> Better fifty years of Europe than a cycle of Cathay.

We need to remember, however, that the word *better* is used in this connection in the European sense. Yet John Stuart Mill is probably right when he says: "Few human creatures would consent to be changed into any of the lower animals, for a promise of the fullest allowance of beastly pleasures; no intelligent human being would consent to be a fool, no instructed person would be an ignoramus, no person of feeling and conscience would be selfish and base, even though they should be persuaded that the fool, the dunce or the rascal is better satisfied with his lot than they with theirs." He puts the case still more effectively in the words: "It is better to be a human being dissatisfied than a pig satisfied; better to be a Socrates dissatisfied than a fool satisfied. And if the fool or the pig is of a different opinion, it is because they only know their own side of the question. The other party to the comparison knows both." It is evident, then, that speech, when most carefully and conscientiously used, is but a feeble reflection of man's inner self. When, on the other hand, we consider man's liability to error, his passive indifference to truth and his proneness to deliberate falsehood, we must admit that language and fact do not often correspond with each other. While it is not true, according to the well-known saying of Talleyrand, that speech was given to man to enable him to conceal his thoughts, that is so employed in numberless instances who shall gainsay?

ZOOLOGY[1]

BY PROFESSOR HENRY E CRAMPTON
COLUMBIA UNIVERSITY

IN the present series of addresses upon the nature and scope of some of the divisions of knowledge, zoology connects the natural sciences with those subjects that deal with human progress in physical, social, political and economic respects. Like the human and other sciences, zoology has arisen from that vague uncoordinated and unresolved mass of knowledge, the natural philosophy of not very remote times, which undertook to comprehend all there was of nature and thought. And again like the other sciences it is as such a branch of relatively late growth. In earlier times few men were sufficiently withdrawn from the affairs of the market-place and commerce and conquest, from politics and government and theological propaganda, to observe the phenomena of nature closely, to reflect upon their observations, and to summarize their deductions in the formularies of natural law. Not until human social structure neared the relatively settled condition of modern times did it become possible for men to differentiate as students of nature solely, rendering their service to the common weal as investigators of the less practical and more remote departments of knowledge. Now the sciences have become so great, so complex and varied, that it is impossible for a single mind to comprehend all that is included in one of them. So widely the impelling energy of research has driven the soldiers of investigation that only when, as in the present series of addresses, they return to the council-fires of an intellectual bivouac can they come to realize how far-flung indeed are the battle-lines of the armies of science—how rich and diversified is the territory from which knowledge has driven ignorance and superstition. And they must realize also how impossible it is for them to conduct their operations at all times in entire independence. The results of physics and chemistry are indispensable weapons for the biologist; geology takes the field with paleontology for the study of fossil forms; while on the other hand the advance posts of zoology provide the students of many a human science with a secure base of operations.

I need not speak of the inter-relations of the several biological sciences, for these have been sufficiently explained in the earlier dis-

[1] A lecture delivered at Columbia University in the series on Science, Philosophy and Art December 11, 1907. Copyright, 1908, by the Columbia University Press.

courses. I shall pass directly to a description of the elements of the present science of zoology and of its history, so far as this is necessary for a clear understanding of the various divisions of the subject and of their connections; and finally I shall endeavor to show how through its human materials zoology articulates directly with other fields of knowledge.

Zoology is the science that deals with the structure, development and inter-relationships of animals, with the workings of their parts, their activities and their relations to their environment, and with the factors that determine their forms. We may recognize two great divisions of the subject, which are concerned respectively with static and with dynamic principles, though the materials of both divisions are the same—namely, all animals throughout the entire range from the highest to the lowest. It is of course clear that morphology—the science of structure—can not be absolutely separated from physiology—the science of function in its widest sense—for we do not know of organic structures that play absolutely no part in an animal's economy, even though this may be a relatively passive one; while on the other hand we do not know—in science at any rate—of a function that is devoid of a material basis. The division is made solely for the sake of analysis, and it depends entirely upon the point of view. Morphology treats adult animals, their different developmental stages, and, more naturally, the remains of extinct animals as though they were arrested in their living, but the dynamic aspects of organic life are so prominent and insistent that it is really impossible to ignore them even temporarily.

Besides dealing with the same materials, the many complicated problems of zoology are still further connected in that the central object of study for both the structural and physiological divisions is evolution. As we look back over the history of the subject from our modern vantage-ground, we can see how zoology began with ancient and medieval natural history, how from this parent stock arose the additional separate branches of anatomy, embryology, paleontology and distribution, how human physiology became comparative physiology which developed later into the broad and deep enquiry into all the activities of animals, their vital relations to one another, and their reactions to and upon the environment; and we can see how all these several branches were vitalized by the great principle of evolution. This whole history shows a steady progress through one phase after another toward the modern study of evolution, though the naturalists of the eighteenth and even of much of the nineteenth century were unconscious, in whole or in part, of the way their observations and views were contributing to the establishment of the doctrine of descent and to the partial description that can now be offered of the natural factors of evolution. As we shall see, the structural analysis of animals

demonstrates the evolution of species as a universal process, while the broad study of the dynamic relations of animals is concerned with the causes of this process, as what we may venture to call the physiology of evolution. In brief, then, the great questions of zoology are the *what* and the *how* of evolution.

In view of the earlier lectures, it is unnecessary to speak at length of classification or taxonomy—the first division of static or structural zoology. Aristotle, who gathered and studied some five hundred of the more common animals of the earth and shore and sea, and the medievalists, Wotton and Ray, Gesner and Aldrovandi, were animated primarily by the instincts of the collector of interesting information. Linnæus, the great figure of the eighteenth century, rendered an immortal service to zoology (and botany, too) by introducing the present ordered system of naming and classifying organisms. But classification was to Linnæus an end in itself, he could not see that it was but a means to the larger end of understanding and expressing evolutionary relationships—that resemblance meant consanguinity. It remained for Erasmus Darwin, the elder St. Hiliare, Lamarck and others to appreciate this inner meaning which so vivifies the otherwise dead details of taxonomy.

The many connected details of animal structure and development and function constitute the threads, as it were, which are interwoven by comparative treatment to form the warp and woof of the fabric of zoology. Classification draws upon this fabric the pattern of genealogical connections, emphasizing those threads that run furthest, the so-called distinctive or diagnostic characters. And though the pattern must be altered here and there as knowledge increases, the zoologist feels that it has a real significance as a representation of evolutionary descent.

As more and more of the lower animals were brought by the microscope from the obscurity of their zoological underworld, as exploration revealed more of the creatures of previously unknown lands, as investigation became more detailed and intensive, comparative anatomy arose as an independent branch of zoology with distinct purposes of its own; and it gained its specific form and character from the studies of the great zoologists of the early nineteenth century—Lamarck, Cuvier, Geoffroy St. Hiliare, Goethe, Owen and Oken. These naturalists dissected and compared the various organic systems of animals, following them as widely as possible from group to group of the numerous vertebrate and invertebrate forms, and they and their followers have placed the doctrine of evolution upon the sure and broad foundation of comparative anatomy. The main principle of this department of zoology is that the varied forms of animals exhibit deep-seated likenesses that place them in groups related to one another

not as the rungs of a ladder as Lamarck supposed, but rather as the branches of a tree or a bush; and such branches again like those of a tree bear smaller branches, and these reach to lesser or greater heights from the base level of primitive organization. Thus, anatomy holds that community of plan is an indication of genetic affinities, while modifications of a common plan exhibit the results of adaptation to different ends through evolution. The framework of the human arm is constructed out of the same elements with the same arrangement that we find in the leg of a cat, the flipper of a seal, the paddle of a whale, and even the wing of a bat, different though these structures are in function—and in these resemblances comparative anatomy discerns evidence of a remote common ancestry of men and whales and bats.

Extended through the study of tissues, or histology, to the unitary elements of organic structure—the cells—comparative analysis has brought the whole realm of organic nature under the sway of a great principle—the cell-doctrine of the botanist Schleiden and the zoologist Schwann. This important principle, propounded in 1838 and 1839, produced an immediate effect in unifying organic creatures, though many years passed before it was formulated in the terms employed to-day. In brief, it is this: All the larger organisms are composed of organs which in turn are constructed of various tissues, like muscle and nerve and connective elements; the tissues finally can be resolved into units of structure, the cells, which agree in possessing a central body or nucleus, and in their protoplasmic substance. The elementary nature of cells is still further demonstrated by the simplest organisms we know, which consist of one cell, nothing more and nothing less; while finally the starting point in the development of higher animals is always a single cell—the egg. Truly these are remarkable facts, when we consider the wide range of animal and plant forms.

Vast as the present knowledge is, the tasks of comparative anatomy are not entirely completed. Though voyages of exploration like those of the *Beagle* with Darwin, the *Rattlesnake* with Huxley, and above all of the famous *Challenger* have gone to all parts of the globe, though countless investigators have devoted their lives to the study of special groups like birds and mammals and insects and molluscs, every year brings to light new forms that must be analyzed and placed; while new discoveries in other departments often make it necessary to reexamine known series in the light of fuller knowledge.

While many naturalists prior to the nineteenth century were interested in the way an animal egg produced an adult organism, it was not until the doctrine of descent energized zoology that comparative embryology attained the independent status that it holds to this day. Harvey in 1650 had perceived that, in his own words, "all animals are in some sort produced from eggs." Bonnet and Haller, of the early

eighteenth century, contended that the germ was a minute replica of the adult which formed it, a *multum in parvo* which simply unfolded and enlarged to produce another adult organism; Wolff, however, showed that this view lacked a basis in fact, and that as we now universally believe, embryonic history is a true development from the simple and unorganized to the progressively more and more specialized later conditions—that it is, in a word, an epigenesis. The great name of the infancy of embryology is that of Von Baer (1792–1876). This acute observer and thinker was struck by the similarity of early stages in the development of quite different adult animals. Birds and reptiles and even mammals pass through stages when they possess gill-slits like those of fishes, related to heart and blood-vessels like the similar structures in lower vertebrates; butterflies and flies and beetles are somewhat alike in their larval stages, when as caterpillars and maggots and grubs they not only resemble one another remarkably but they are also very like worms. Under the influence of the evolution doctrine, then becoming more generally accepted, Von Baer and a host of followers extended the science of comparative embryology until Haeckel in 1866 ventured to state the "Law of Recapitulation," or the "Biogenetic Law," in the following rigid terms: Ontogeny recapitulates phylogeny. (The development of an individual reviews the past history of its species.) Led by their enthusiasm many of the later nineteenth century zoologists followed too implicitly the lines of the embryonic record, though Haeckel himself, the most radical advocate of the law, pointed out that there are many serious omissions in the narrative, that false passages are inserted as the result of purely larval and embryonic needs and adaptations, while many alterations in the way of anachronisms have been made. Of late years there has been a strong reaction from the complete acceptance of the principle as a reliable mode of interpreting embryonic histories. But I believe zoologists generally feel that used with due caution the law has a high value for the student of evolution, and they realize that embryology is perhaps more significant in other respects than in showing exactly how in past times any given species has evolved. The present tasks in this department, now so thoroughly investigated, are to distinguish between the false and the true portions of the record, between the new and the old, and to ascertain the physiology of development, in order to gain a more complete knowledge of racial history and of the dynamics of organic nature.

The study of the fossil remains of animal organisms, or paleontology, is the fourth division of structural zoology, which as an independent branch dates back to the time of Cuvier, scarcely a hundred years ago. Vestiges of creation were indeed known long before that time, but they were variously regarded as freaks of geological forma-

tion, *lusus naturæ,* as remains of creatures stranded by tidal waves or cataclysms like the traditional flood, or again as the remains of animals formed by a process of spontaneous generation in the depths of the earth that had failed to reach the surface. It was Leonardo da Vinci of the fifteenth century who, anticipating the naturalists of later times, believed these vestiges are what common-sense says they are—simply relics of creatures that lived when the earth was younger. Cuvier was in a true sense the founder of paleontology; though a special creationist, he recognized that beneath their differences there were fundamental likenesses between recent and extinct animals. He assumed that cataclysms had closed the several geologic epochs whereupon new series of animals and plants were created upon the same general working-plans employed in earlier ages; thus he combined the idea of change in geologic time with a belief in supernatural creation. When, however, Lyell led geologists and others to abandon the cataclysmic hypothesis in favor of the doctrine of uniformitarianism, when the series of known fossil forms increased and the intrinsic value of the paleontological evidence became clearer, the doctrine of evolution finally claimed this field also as its own.

The nature of the case is such that the fossil record must remain incomplete, perhaps forever. For not all the animals of former times possessed hard parts capable of resisting the disintegrating forces of organic and inorganic nature, the rocky tombs of those animals that were embedded in the sands and silts have been crushed and rent asunder by the very geological agencies that at first constructed them. More than half of the earth's surface is now under water, while by no means all of the dry land is accessible. Only a few scratches have been made here and there upon the earth's hard crust, so it is little wonder that the testimony of the rocks is halting and imperfect. But what there is, a rapidly growing body of cold, hard facts, is in itself conclusive evidence of the reality of evolution. Researches like those of Von Zittel, Cope, Hyatt, Marsh, Osborn and Scott, demonstrate that, when they appear at all, the great groups or *phyla* of animals and their subdivisions succeed one another in that chronological order which comparative anatomy and embryology have independently shown is the order of their evolution. Then, too, there are those fossil types that link together groups now so widely separated, like *Archeopteryx,* which is at once a feathered reptile and a bird with reptilian tail and skull and limbs. And there are the marvelously perfect series of fossils like those which demonstrate the evolution of modern horses and elephants; and, finally, as the special creationist Louis Agassiz himself showed, some fossil series parallel very closely the embryonic record in modern types. No field opens more invitingly than that of the paleontologist. His tasks are to search the rocks everywhere for new fossil types to

fill in the gaps of the lines of descent that at best can only be interrupted lines, and to show how these lines lead to modern forms or to divergent kinds that have ceased to be. And he will compare his results with those of students in other fields, who will assist him to formulate the working-plans for his own labors.

Zoo-geography is the last branch of structural zoology to attain an independent status. Many observers from Buffon onward had been struck by the fact that species of animals are not uniformly distributed over the earth, that they differ more widely as the observer passes to more and more remote localities, with more different climatic and other environmental conditions. But the meaning of these peculiarities was obscure until the doctrine of descent cleared their vision. Wagner, Louis Agassiz and Dana, Sclater, Murray and Wallace were the leaders of those who have brought together the immense mass of modern knowledge of animal distribution. From this many well-established principles relating to descent have been derived, though these have a deeper interest in connection with the dynamic problem as to whether differences in environment can actually cause species to transform, as Lamarck supposed. As a statement of the results in this apparently simple, but really quite complicated field would be misleading, I fear, from its brevity and general form, I will venture to present just one conclusion. Geographical isolation corresponds in a general way with the divergence of species in their evolution from common ancestors; thus widely separated areas have faunas that differ more widely in zoological respects than do those of neighboring or connected countries. For example, the Australian region has been cut off for a relatively long period from neighboring continents, and in correspondence with this isolation it contains the only egg-laying mammals known, as well as all of the pouched mammals like the kangaroo, with a few exceptions like our American opossum. Furthermore, groups of isolated oceanic islands, like the Galapagos and Azores and the clusters of Polynesia, are inhabited by lizards and birds and insects which resemble most closely the species of the nearest bodies of land. Such resemblances are most reasonably interpreted as indicating that the original progenitors of the island colonies were stragglers from the nearest mainland, whose descendants have undergone divergent evolution during succeeding generations.

Having, then, this vast store of fact and principle amassed through centuries by countless students, the zoologist is entitled to speak positively when he finds a law like the doctrine of evolution that reviews and summarizes the whole range of animal structure. The well-established facts of zoology are the reasons why he asserts with a decision often mistaken for dogmatism that evolution is a real process. The further question, why is nature so constituted that evolution is

true, is an enquiry that does not fall within the limits of zoological science.

We now come to the second great division of zoology, which as a whole is concerned with broad and deep enquiry into the workings of nature; it is natural history in the best sense. Prior to the time of Darwin attempts to solve the kinetic problems of the organic world were hampered by anthropomorphism and narrowness of view, as well as by paucity of facts. But since then, owing to the immense influence of the works of that great naturalist, so much attention has been given to the fundamental problems of life that it is now possible to correlate many principles which describe not only the *fact* of evolution but many of the *factors* as well. And in this modern development wide observation has led so directly to extensive experiment that we may justly characterize the present period as an age of experimental zoology. Just as all the apparently disconnected studies of structural zoology deal with one matter—evolution—so in the sphere of experimental zoology all the radii converge upon the study of the factors and method of species transformation.

We can only mention some of the modern departments which have yielded brilliant results, such as cytology, experimental embryology, experimental fertilization and regeneration. But we may point out that the general problems in these various fields deal like the problem of evolution itself with an analysis of the internal and external influences that determine the final adult conditions of species. For example, the adult salamander possesses a specific structure, in a state of balance or adaptation, that is the final result of an evolution process up to the present time; this same specific condition is the goal of the changes through which the salamander's egg and embryo pass in development; it is the goal also that may be reached by even a portion of a divided salamander's egg; while finally it is the goal of the regenerative processes that enable a salamander from which a leg has been cut off to reproduce the missing part. Everything centers then about the question as to the origin of adult specific forms, which exhibit adaptation.

Realizing this, we may pass on immediately to consider how through the study of adaptation, Darwin was led to formulate his potent theories, which have been the basis for recent progress. As the other speakers upon biological sciences have already stated, the most striking feature of animals and plants is their adjustment to their vital conditions. An organism that seems so sufficient unto itself, so capable and independent, is nevertheless inextricably interlocked with its surroundings, for its very substance is composed of materials which with their endowments of energy have been wrested from the environment. An animal that is pressed upon by the substances of the outer world, that is played upon by various energies, and is attacked on all sides by

innumerable foes, finds itself involved in a warfare that is tragically one-sided; and it must prevail over all its many foes or it must acknowledge defeat and pay the penalty for unconditional surrender, which is death—so stern and unyielding is that vast totality we individualize as the environment. The generalized biological formula, then, for the turmoil of nature is *adaptation = life*.

Here, then, is the heart of the mystery. How has this universal condition of adaptation been brought about? What have animals within them that might determine their greater or less efficiency? What external influences, if any, are capable of directing the efforts of living creatures to meet their enemies? How are modifications perpetuated when they have arisen? To many of these questions Darwin, Weismann, Mendel, De Vries and others have found answers, not complete or perfect, it is true, but they have relegated to the past the former reply that supernatural causes must be invoked to account for nature. Science is convinced that the study of nature's workings at the present time reveals natural factors which are competent to account for much of the wonderful process of evolution.

As every one knows, the works of Darwin inaugurated our recent era in biology. In 1858, Darwin and Wallace announced the doctrine of natural selection, and, in 1859, Darwin published the "Origin of Species," a book that has proved a veritable Magna Charta of intellectual liberties, for as no other single document before or since it has released the thoughts of men from the trammels of unreasoned conservatism and dogmatism. And its influence has been felt far beyond the borders of biological science—it has extended to the very confines of organized knowledge everywhere. But it is a mistaken popular notion, and one of the hardest to drive from the mind of the layman in science, that Darwin founded the doctrine of evolution by the book mentioned and those that followed. The fact of evolutionary descent had been established long before, while even some of the special points of Darwin's theories as to method had been anticipated. Had Darwin never lived, I believe that evolution would still be accepted and taught at the present day. But Darwin rendered two immortal services to science. During the twenty years that elapsed between the first conception of his theories and the date of their publication, he marshalled in orderly array all the biological data obtainable which proved the transformation of species, including the previously unrecognized body of evidence afforded by the domesticated animals. In the second place, in his doctrine of natural selection he presented for the first time a partial consistent program of nature's method of accomplishing evolution. Darwin did not believe that this explanation was final or even complete, whatever his opponents of the time or critics of the present might contend.

What, now, is the doctrine of natural selection, as Darwin propounded it? All animals vary; every individual differs from others of its kind, even from its closest kin and from its parents in some or many particulars and to different degrees. Whatever the causes, the fact of variation stands unquestioned. Some variations are of course due to direct environmental influence, and to these Buffon attributed an excessive importance; other deviations from the parental or average specific type are no doubt due to indirect effects of the environment, as Lamarck contended. But there are countless other variations that can not be so explained, some of them indeed appearing before an individual is subjected to the action of the environment, and these are the congenital variations due to some constitutional even if unknown causes. These seemed to Darwin to be the most important in evolution.

The second element of the doctrine is that over-production, or rather over-*re*production, is a universal characteristic of living things. The normal rate of multiplication is such that any given form of animal or plant would cumber the earth or fill the sea in a relatively brief period of time. We now know that a bacillus less than $\frac{1}{5000}$ of an inch in length multiplies under normal conditions at a rate that would cause the offspring of a single individual to fill the ocean to the depth of a mile in five days. "Slow-breeding man," wrote Darwin, "has doubled in the past twenty-five years." But excessive multiplication is checked by the third part of the whole process, namely, the struggle for existence, that fierce unequal warfare waged by every individual with its inorganic surroundings, with other species of living things, and with others of its own kind. Indeed where members of the same species compete, the struggle often surpasses in ferocity the warfare with other organisms. Communal organisms only are in part exceptions, for in these the battle involves the clash of community with community more than it does the interests of the individuals of a single colony. To what, now, do these elemental processes lead, asks Darwin. Though all seek to maintain themselves, all can not possibly live when only a few can find sustenance or can escape their enemies. Naturally those which possess any advantage whatsoever, that vary ever so slightly in the direction of better adjustment would survive where their brethren perish. And this is nature's selective process, with its positive and negative aspects—the survival of the fittest and the elimination of the unfit. Now we can see why adaptation is a universal characteristic of species—there are no unadapted. If such there were, they have fallen long ago, and the world knows them no more. True it is that perfection is not attained by any creature, but it must establish a *modus vivendi* or it perishes. Thus, Darwin held, nature perfects species by dealing directly with favoring derivations that are mainly congenital, and so through these it selects the herditary factors that determine favorable variations.

In one fundamental respect the doctrine is incomplete, as it fails to explain the causes for the variations with which selection deals. It accounts for the perpetuation of favoring variations, but it does not account for their inception. Because of this defect, investigators reacted from the academic discussion of Darwin's original doctrine, and returned to deeper and wider study of heredity and variation with brilliant success. Some neo-Darwinians have endeavored to make the selective process an originative influence—notably Roux, and Weismann in his theory of germinal selection. Darwin himself added the subsidiary process of sexual selection, which regards the preference by one sex of characteristics of the opposite sex as a conserving influence. But while such attempts have failed, zoologists believe, to explain the whole method of evolution, much of the process has been demonstrated more and more clearly with further study. The laws of fluctuating variations have now been formulated with mathematical accuracy, through the employment of the statistical methods used earlier by anthropologists like Quetelet. The studies of Galton and Pearson, Boas, Weldon and Davenport have demonstrated that structural and physiological characters of men, of other animals, and of plants as well, vary according to the formulas of chance or error—a result they say that follows from the combined influence of innumerable and independent factors. Variation is a natural phenomenon of chance. Furthermore, the reality of the selective process has also been proved by statistical methods. Bumpus's English sparrows, Weldon's snails and crabs, and many other cases show that the individuals which depart widely from an average condition, or that are uncorrelated in their organization, are marked for destruction.

In brief, while natural selection has not been established as in any sense an originative process, it has been demonstrated, I believe, as a judicial process. For we may liken the many varied vital conditions to jurymen, before whom every organism must present itself for judgment; and a unanimous verdict of complete or at least partial approval must be rendered, or the organism must perish.

The phenomena of biological inheritance, however, have demanded the greater attention of Darwinian and post-Darwinian investigators. A complete statement of the whole of evolution must show how species maintain the same general characteristics through inheritance, how the type is held true with passing generations, and it must also show how new characters may enter into the heritage of any species to be transmitted as organisms transform in evolution.

The earliest naturalists had accepted the fact of inheritance as self-sufficient. The resemblance between parent and offspring did not demand an explanation any more than variation. When Buffon, however, added the element of species transformation, he held that external

influences could bring about a directly responsive organic change, which he assumed was inherited. Lamarck developed the well-known view, previously advocated by Erasmus Darwin, that indirect responses to the environment could be fixed in inheritance as so-called "acquired characters," meaning by this phrase that such characters are acquisitions during the life-time of an individual as the effects of disuse or unusual use, or of new habits. Coming again to Darwin, we find that he endeavored to support Lamarck's doctrine and to supplement his doctrine of selection by adding the theory of pangenesis. According to this every cell of every tissue and organ of the body produces minute particles called gemmules, which partake of the characters of the cells that produce them. The gemmules were supposed to be transported throughout the entire body, and to congregate in the germ-cells, which would be in a sense minute editions of the body which bears them, and would so be capable of producing the same kind of a body. If true, this view would lead to the acceptance of Lamarck's or even Buffon's doctrine, for changes induced in any organ by other than congenital factors could be impressed upon the germ-cell, and would then be transported together with the original specific characters to future generations. Darwin was indeed a good Lamarckian.

But the researches of post-Darwinians, and especially those of the students of cellular phenomena, have demonstrated that such a view has no real basis in fact. Many naturalists, like Naegeli and Wiesner, were convinced that there was a specific substance concerned with hereditary qualities as in a larger way protoplasm is the physical basis of life. It remained for Weismann to identify this theoretical substance with a specific part of the cell, namely, the deeply-staining substance, or chromatin, contained in the nucleus of every cell. Bringing together the accumulating observations of the numerous cytologists of his time, and utilizing them for the development of his somewhat speculative theories, Weismann published in 1882 a volume called "The Germ-Plasm," which is an immortal foundation for the later work on inheritance. The essential principles of the germ-plasm theory are somewhat as follows: The chromatin of the nucleus contains the determinants of hereditary qualities. In reproduction, the male sex-cell, which is scarcely more than a minute mass of chromatin provided with a thin coat of protoplasm and a motile organ, fuses with the egg, and the nuclei of the two cells unite to form a double body, which contains equal contributions of chromatin from the two parental organisms. This gives the physical basis for paternal inheritance as well as for maternal inheritance, and it shows why they may be of the same or equivalent degree. When, now, the egg divides, at the first and later cleavages, the chromatin masses or chromosomes contained in the double nucleus are split lengthwise and the twin portions separate to go into

the nuclei of the daughter cells. As the same process seems to hold for all the later divisions of the cleavage-cells whose products are destined to be the various tissue elements of the adult body, it follows that all tissue-cells would contain chromatin determinants derived equally from the male and female parents. As of course only the germ-cells of an adult organism pass on to form later generations, and as their content of chromatin is derived not from the sister-organs of the body but from the original fertilized egg, there is a direct stream of the germ-plasm which flows continuously from germ-cell to germ-cell through succeeding generations. This stream, be it noted, does not flow circuitously from egg to adult and then to new germ-cells, but it is direct and continuous, and apparently it can not pick up any of the body-changes of an acquired nature; indeed, it is doubtful whether such changes can reach the germ-cells at all, for the path is not traversed in that retrograde direction.

It must be clear, I am sure, that this theory supplements natural selection, as it describes the physical basis of inheritance, it demonstrates the efficiency of congenital or germ-plasmal factors of variation in contrast with the Lamarckian factors, and finally in the way that in the view of Weismann it accounts for the origin of variations as the result of the commingling of two differing parental streams of germ-plasm.

At first, for many reasons, Weismann's theories did not meet with general acceptance, but during recent years there has been a marked return to many of his positions, mainly as the result of further cytological discoveries, and of the formulation of Mendel's law and of De Vries's mutation theory. The first-named law was propounded by Gregor Mendel on the basis of extensive experiments upon plants conducted during many years, from 1860 on, in the obscurity of his monastery garden at Altbrünn, in Germany. It was rescued from oblivion by De Vries who found it buried in a mass of literature and brought it to light when he published his renowned mutation theory in 1901. Mendelian phenomena of inheritance, confirmed and extended by numerous workers with plants and animals, prove that in many cases portions of streams of germ-plasm that combine to form the hereditary content of organisms may retain their individuality during embryonic and later development, and that they may emerge in their original purity when the germ-cells destined to form a later generation undergo the preparatory processes called maturation. They demonstrate also the apparent chance nature of the phenomena of inheritance. I think the most striking and significant result in this field is the proof that a particular chromosome or chromatin mass determines a particular character of an adult organism, which is quite a different matter from the reference of all the hereditary characters to all of the chro-

matin. Professor Wilson has brought forward the convincing data showing that the complex character of sex in insects actually resides in or is determined by particular and definite masses of this wonderful basis of inheritance.

Mendel's principles also account in the most remarkable way for many previously obscure phenomena, such as reversion, and again, the case where a child resembles its grandparent more than either of its parents; these seem to be due, so to speak, to the rise to the surface of a hidden stream of germ-plasm that had flowed for one or many generations beneath its accompanying currents. I believe that the law is replacing more and more the laws of Galton and Pearson, formulated as statistical summaries of certain phenomena of human inheritance taken *en masse*. According to Galton's celebrated law of ancestral inheritance, the qualities of any organism are determined to the extent of a certain fraction by its two parents taken together as a mid-parent, that a smaller definite fraction is contributed by the grandparents taken together as a mid-grandparent, and so on to earlier generations. But Mendel's Law has far greater definiteness, it explains more accurately the cases of alternative inheritance, and it may be shown to hold for blended and mosaic inheritance as well.

De Vries's mutation theory has already been explained in an earlier address by Professor Richards. It is clearly not an alternative but a complementary theory to natural selection, the germ-plasm and Mendelian theories. Like these last, it emphasizes the importance of the congenital hereditary qualities contained in the germ-plasm, though unlike the Darwinian doctrine it shows that sometimes new forms may arise by sudden leaps and not necessarily by the slow and gradual accumulation of slight modifications or fluctuations. The mutants like any other variants must present themselves before the jury of environmental circumstances, which passes judgment upon their condition of adaptation, and they, too, must abide by the verdict that means life or death.

From what has been said of these post-Darwinian discoveries, the Lamarckian doctrine, which teaches that acquired non-congenital characters are transmitted, seems to be ruled out. I would not lead you to believe that the matter is settled. I would say only that the non-transmission of racial mutilations, negative breeding experiments upon mutilated rats and mice, the results of further study of supposedly transmitted immunity to poisons—that all these have led zoologists to render the verdict of "not proved." The future may bring to light positive evidence, and cases like Brown-Séquard's guinea-pigs, and results like those of MacDougal with plants and of Tower with beetles may lead us to alter the opinion stated. But as it stands now most investigators hold that there are strong general grounds for disbelief in the principle, and also that it lacks experimental proof.

The explanation of natural evolution given by Darwinism and the principles of Weismann, Mendel and De Vries, still fails to solve the mystery completely, and appeal has been made to other agencies, even to teleology and to "unknown" and "unknowable" causes as well as to circumstantial factors. A combination of Lamarckian and Darwinian factors has been proposed by Lloyd Morgan, Mark Baldwin and Professor Osborn, in the theory of organic selection. The theory of orthogenesis propounded by Naegeli and Eimer, now gaining much ground, holds that evolution takes place in direct lines of progressive modification, and is not the result of apparent chance. Of these and similar theories, all we can say is that if they are true, they are not so well-substantiated as the ones we have reviewed at greater length.

The task of experimental zoology is to work more extensively and deeply upon inheritance and variation, combining the methods and results of cellular biology, biometrics and experimental breeding. We may safely predict that great advances will be made during the next few years in analyzing the method of evolution; and that a few decades hence men will look back to the present time as a period of transition like the era of re-awakened interest and renewed investigation that followed the appearance of the "Origin of Species."

We must now state distinctly and fairly the present views of science regarding man's place in nature. Surely human evolution is a subject that falls within the scope of zoological investigation, unless indeed it can be shown that the human species is exempt from the control of those laws of nature that hold sway over the animate world elsewhere, unless something can be found which excludes man from the animal kingdom. Notwithstanding the most prolonged search not only by zoologists but as well by those who have been unfriendly to the doctrine of descent, the study of man and of men has revealed nothing essentially unique. What is known of the anatomy, development and fossil relations of man is summarized in the statement that he belongs to the genus and species *Homo sapiens,* placed with the apes and some other forms in the order primates because of agreement in certain peculiar details. The primates agree with the carnivora, rodents and many other orders in the characteristics of the class mammalia, which in turn is only a branch of the limb vertebrata or chordata, which also bears the avian, reptilian, amphibian and fish branches. And all the vertebrates including man agree with the varied groups of invertebrates in their cellular constitution and in the similar protoplasmic basis of life. As in these structural respects, so in physiological activities and in environmental relations the human species proves more surely with increased knowledge to be only one of the terms in the extensive series of animals. Indeed, the scientific monism of Haeckel and Clifford

ventures to assert that man and all other living creatures are one with the mind-stuff of the inorganic world—and this, I believe, is only the logical extension of the genetic and mechanistic hypotheses. However this may be, science holds that human structure is animal structure, and that human lives are biological phenomena.

Man is structurally inferior in many respects to some of his zoological relatives—he is a degenerate, indeed, in many parts of the alimentary, muscular and skeletal systems—yet he finds in the higher development of his nervous system an advantage that offsets the weaknesses of his constitution elsewhere. He holds his supreme place by virtue only of superior and more effective control of his organization.

Behind their seeming structural differences, only one real distinction can be found to separate man from the apes—the higher development of the brain. The erect posture, the correlated modifications of skeletal and muscular structures, and apparently the powers of speech and reason, seem to be dependent upon the enlargement of this organ, which, so to speak, has pushed the face around under the brain-case. Therefore he who would be ὁ ἄνθρωπος—he who looks ahead—must needs stand erect in order to prevent his eyes from looking straight into the ground. But the most careful analysis has so far failed to detect any essential differences in either structural or functional respects between the human brain and the corresponding organs of the higher apes. In brief, then, differences in degree and not in kind or category seem to distinguish man from the apes—as far as science goes.

Moreover, the human body is a veritable museum of rare and interesting relics of antiquity—the useless vestiges and rudiments of structures that are more developed in other animals. The complete coat of hair of the embryo, the disappearing thirteenth rib, the ape-like and transitory clasping muscle of the new born infant's hand, the curvature of the lower limb and the hand-like foot of the embryo, these and scores of other characters are mutely eloquent witnesses to the past history of change that has brought man to his present place in nature. Embryology gives a vast amount of additional independent testimony. For like all embryo mammals and birds and reptiles, the human embryo possesses gill-slits, and fish-like heart and brain. Above all it begins life as a single cell. Zoology asks: What can these things mean, if they do *not* mean evolution and a common ancestry with other forms? The objection that no one has ever seen a one-celled organism evolve into a many-celled one, or into a fish or an ape, or into a man, the zoologist answers by placing upon the table the evidence that a single-cell, the human egg, actually does compass the whole history in becoming the almost inconceivably complex adult organism. The process *can* take place for it *does* take place. Paleontology also presents evidence relating to the history of our species, as the third support

of the tripod upon which rests the doctrine of human evolution. While opinions differ with respect to the remains of man taken from the many caves and mounds of Europe and America, there is but one generally accepted view regarding the ape-man *Pithecanthropus* of the Javan rocks. The remains of this animal prove among other things that its brain was intermediate between the average ape brain and the average human brain, that the animal was indeed an ape-man and nothing else.

Science holds, furthermore, that natural factors alone have brought about human evolution. While it is true that the explanation is no more complete for this special instance than it is for animals in general, yet the human species is not exempt from the control of the known factors, like those which cause variation or govern inheritance. Indeed, some of the significant facts of heredity have been first made out in the human species. Can we doubt the reality of selection and the struggle for existence when scores perish annually in the conflict with extreme degrees of temperature and other environmental forces, when as a result of the unceasing combat with bacterial enemies alone the casualties on the human side number in our country more than a hundred thousand annually?

To the zoologist it seems strange that there is so much opposition to the doctrine of human evolution. In truth he finds this to be proportional to misunderstanding of the facts, for when the evidence is produced—Pelion piled on Ossa—any lingering doubts the observer might have are crushed by an irresistible weight of testimony. After all, our kind is but one of the many hundreds of thousands of living species; and viewing the matter from the calm, impersonal standpoint of scientific study, the fact that he is himself a human being does not distort the investigator's vision, for his perspective is corrected and rectified by the instruments of scientific method. He finds no difficulty in accepting human evolution as a scientific fact—that is, true as far as science goes.

In extending its broad comparative studies into the field of complex and intricate human nature, zoology touches numerous other sciences that might seem at first sight to be entirely independent, or at the most only casually connected with it. I shall venture to point out where analysis within the field of zoology has produced results which have a high and immediate value for students of anthropology, psychology, sociology and ethics.

When they deal with the evolution of the human species from pre-human animals, the anthropologist and the zoologist are brought by their similar interest upon common ground; and when they pass on to explore the field of human diversity where lie the complex problems

of racial evolution, they are still fellow-workers, for in the case of physical anthropology of human races at least the methods are the same which are employed in zoology generally. Of course it would be absurd for any one to contend that all the problems of anthropology are strictly zoological questions; to qualify here an investigator must be familiar with linguistics, racial customs and beliefs, and many subjects that are as such apparently outside the limits of zoology. But unless a sharp line is to be drawn between the slow origin by evolution of the human species and the later history of this species, the comparative and genetic methods of analysis which render the earlier process intelligible can scarcely fail to be of service in dealing with the latter. The great danger, which the zoologist himself clearly sees, arises from a tendency to ignore the detail in formulating the general, to oversimplify the problems of the more recent history. For human conscious elements are so complex and plastic that the problems of racial evolution are rendered far more intricate than the broad zoological analysis of the origin of man as a species.

Psychology, in the second place, is a subject that is related to zoology by the closest of ties, the bond of union being again the common human element. To be sure, the zoologist finds enough in his own field to occupy him fully, but the comparative study of nervous systems, and of the reflex, instinctive, intelligent and reasoned responses of animals brings him inevitably to consider the relation of human mentality and consciousness to the other terms of the animal series. Dealing strictly as a zoologist with animals and their lives, the investigator learns that the machine-like regularity of reflex and instinctive activities is correlated, broadly speaking, with simple nervous organization; that the plasticity of intelligent response is not gained until the physical basis becomes far more complicated; and finally that reason and consciousness are in some way bound up with the higher development of the nerve-centers or ganglia that make up the brain. So the zoologist is inclined to believe that the comparative series of mental grades which culminates in the consciousness, or rather the self-consciousness, of the adult human organism, and the series of developmental stages through which the human mental structure passes during infancy and childhood, indicate an evolution in time of the psychic being of man. Whatever may be the outcome of further study, Romanes, Lloyd Morgan, Forel and Thorndike, among those of modern times, have demonstrated that the genetic methods of zoology are useful instruments for the psychologist, who, I believe, is becoming more and more a student of zoological materials as he realizes the advantage of studying the simpler psychic phenomena of animals lower than man.

In venturing to speak of the relation of zoology to sociology and ethics, I am well aware that I shall be charged with straying beyond

the confines of my subject. But if the student of lower forms should find well-defined principles of biological association and principles of animal conduct, it is not only his privilege, it is in a sense his duty as well to bring these to the consideration of the students of human social and ethical relations. Unless in these matters there has been a break in the continuity of evolution, the simpler relations to be observed in lower animals must surely possess a profound interest—and perhaps more.

In a true sense, any of the many-celled animals is a community, whose constituent members are the differentiated tissue-cells, which have undertaken the various tasks of digestion, contraction, sensation and the rest. By far the majority of animals are cell-communities of this nature. Considering these as individuals, though of a secondary order, we find some communities made up of several animals which have banded together for mutual support and defense, giving us as in the wolf-pack a counterpart of the lowest associations of savage men. But among insects especially we find colonies of numerous multicellular individuals which may be so rigidly specialized for the performance of certain tasks that we can not avoid the use of terms applied to civilized human groups in describing their differentiation and division of labor. Some colonies of bees comprise queens and drones and only one kind of sterile workers, though when newly hatched these last serve as guards and nurses, taking the field as foragers for pollen and honey only later in life. In various ant-colonies we shall find workers who serve as herdsmen, devoting their time to the care of the ant-cattle or aphids; again there are masons, and gardeners, and carpenters, and soldiers of various ranks, while in the honey-ant some individuals may serve as living receptacles for the tribal stores of food. Each kind undertakes one of the tasks that are vital for the life of the community as a whole. Instinctive and unreasoned their activities may be, and undoubtedly are, but the economic and social relations of the component members of the colony are strikingly analogous to certain fundamental phenomena of human societies. But still more wonderful are the cases that may be found among hornets and wasps. A fertile female overwinters and places her first-laid eggs in the chambers of a simple nest that she constructs herself. When the young of the first brood hatch, she provides them with food, enlarges the nest, and continues the task of egg-laying, while her first offspring relieve her of her former duties as they become able. They enlarge the nest, they care for their younger kin as they hatch, they forage abroad for the food-supplies for the colony. And so the community that begins life in the early spring with a solitary animal advances during the passing weeks to a degree of complexity that is truly astounding. As an epitome of insect social evolution it gives in a few weeks a review of the process that in other

forms of social insects with stable colonies, or in the analogous human history, has demanded centuries of time.

As we review these different kinds of individuals—the one-celled animal, the many-celled creature and the community—we see that each one must obey certain rules of nature. It must preserve itself, it must perpetuate its kind, and, if it be a member of a higher community, it must act in the interests of others and of the whole group. Do we not find, then, biological definitions of right, and evil, and duty to others as well as to self? Do we not see why altruism has grown out of egoism as communities have evolved at the behest of nature?

But still, facts like these are purely zoological facts. To be well within his rights, the zoologist should perhaps only suggest their usefulness for the analysis of human social relations and obligations. It is for the sociologist and the student of comparative ethics to employ and apply them according to the principles of the genetic method, should they see fit to do so.

In closing, may I say a few words regarding the attitude of the zoologist toward his problems and his results. He may maintain this attitude because of a certain temperament which leads him and his fellows to enter the field of science as investigators. While this may be true, it is also true, I believe, that the subjects of their study, the principles they may discern in nature's order, and their methods of analysis have a profound reflex effect upon not only the contents of their minds but upon their mental machinery as well. The zoologist, like his fellow men of science, learns early that he must adopt an impersonal attitude, for emotion and purely human interest are disturbing elements that prevent him from attaining the purpose of the investigator—which is, to ascertain and verify facts, to classify them logically, so as to derive from them the summaries which like so much "conceptual short-hand" are available for others as well as himself. Science is "organized knowledge," as Pearson defines it; "organized common sense" in Huxley's phrase; and like other men of science the zoologist learns to view his great common-sensible principles like the doctrine of descent, not as absolute eternal verities, but only as summaries up to date, as working programs, to employ Professor Wilson's concise phrase. This *may* be pragmatism; it is certainly science.

But surely this does not mean that principles like the one mentioned are so many gratuitous assumptions. Like the principle of gravitation and the law of the conservation of energy, zoological laws have the strength and approximate finality of all the wide range of facts that they summarize. And these are many—a vast store of detail and generalization accumulated during decades and centuries by those who have sought upon the mountains or in the abysses of the seas for new knowledge, but countless students who have spent their lives in the field

and in the laboratory in the endeavor to pierce still further with trained insight into the mysteries of nature. And these are their results.

No one realizes more than the zoologist that his knowledge is incomplete. No one can see more clearly than he that his intellect evolves, like the great sweeping tide of things and events—the nature he studies and of which he is but a conscious atom. The investigator soon learns to withhold final judgment, agreeing with Clifford that the primary conditions for intellectual development are the plasticity and openness of mind that dogmatism and finality destroys. The end of zoology can not be until the end of all knowledge.

Conscious, then, of the impossibility of reaching absolutely final knowledge, why does the investigator continue to search the world of nature as he does? Because of that ingrained and insatiable human curiosity to learn, because of the human discontent with the attained. Antæus-like, every fresh contact with the world of law and order infuses new energy into his veins for further endeavor. "Und es treibt und reisst ihn fort, rastlos fort . . ." not, it is true, in the wandering blindness of Schiller's huntsman, for his human vision is aided by the instrument of scientific method with which he can *almost* perceive the infinitely great and the infinitely small.

Glorying in the great achievements of his science, reveling like the mathematician in the ordered assemblage of related and organized knowledge, the student of zoology joins his fellows yet again for a renewed attack upon the distant ramparts of the unknown, deriving courage and inspiration from the motto: *Ignoramus, in hoc signo laboremus.*

EXPERIMENTS WITH THE LANGLEY AERODROME[1]

By Dr. S. P. LANGLEY
SECRETARY OF THE SMITHSONIAN INSTITUTION

THE experiments undertaken by the Smithsonian Institution upon an aerodrome, or flying machine, capable of carrying a man have been suspended from lack of funds to repair defects in the launching apparatus without the machine ever having been in the air at all. As these experiments have been popularly, and of late repeatedly, represented as having failed, on the contrary, because the aerodrome could not sustain itself in the air I have decided to give this brief though late account, which may be accepted as the first authoritative statement of them.

It will be remembered that in 1896 wholly successful flights of between one half and one mile by large steam-driven models, unsupported except by the mechanical effects of steam engines, had been made by me. In all these the machine was first launched into the air from "ways," somewhat as a ship is launched into the water, the machine resting on a car that ran forward on these ways, which fell down at the extremity of the car's motion, releasing the aerodrome for its free flight. I mention these details because they are essential to an understanding of what follows, and partly because their success led me to undertake the experiments on a much larger scale I now describe.

In the early part of 1898 a board, composed of officers of the army and navy, was appointed to investigate these past experiments with a view to determining just what had been accomplished and what the possibilities were of developing a large-size man-carrying machine for war purposes. The report of this board being favorable, the Board of Ordnance and Fortification of the War Department decided to take up the matter, and I having agreed to give without compensation what time I could spare from official duties, the board allotted $50,000 for the development, construction and test of a large aerodrome, half of which sum was to be available immediately and the remainder when required. The whole matter had previously been laid before the board of regents of the Smithsonian Institution, who had authorized me to

[1] Dr. Langley's pioneer experiments in aerial navigation are of such contemporary interest that we reproduce this article, written shortly before his death, and printed in the Annual Report of the Smithsonian Institution for 1904.

take up the work and to use in connection with it such facilities of the institution as were available.

Before consenting to undertake the construction of this large machine, I had fully appreciated that, owing to theoretical considerations, into which I do not enter, it would need to be relatively lighter than the smaller one; and later it was so constructed, each foot of sustaining surface in the large machine carrying nearly the same weight as each foot in the model. The difficulties subsequently experienced with the larger machine were, then, due not to this cause, but to practical obstacles connected with the launching, and the like.

I had also fully appreciated the fact that one of the chief difficulties in its construction would lie in the procuring of a suitable engine of sufficient power and, at the same time, one which was light enough. (The models had been driven by steam engines whose water supply weighed too much for very long flights.) The construction of the steam engine is well understood, but now it would become necessary to replace this by gas engines, which for this purpose involve novel difficulties. I resolved not to attempt the task of constructing the engine myself, and had accordingly entered into negotiations with the best engine builders in this country, and after long delay had finally secured a contract with a builder who, of all persons engaged in such work, seemed most likely to achieve success. It was only after this contract for the engine had been signed that I felt willing to formally undertake the work of building the aerodrome.

The contract with the engine builder called for an engine developing 12 brake horsepower, and weighing not more than 100 pounds, including cooling water and all other accessories, and with the proviso that a second engine, exactly like this first one, would be furnished on the same terms. The first engine was to be delivered before the close of February, 1899, and the frame of the aerodrome with sustaining surfaces, propellers, shafting, rudders, etc., was immediately planned, and now that the engine was believed to be secured, their actual construction was pushed with the utmost speed. The previous experiments with steam-driven models, which had been so successful, had been conducted over the water, using a small house-boat having a cabin for storing the machine, appliances and tools, on top of which was mounted a track and car for use in launching. As full success in launching these working models had been achieved after several years spent in devising, testing and improving this plan, I decided to follow the same method with the large machine, and accordingly designed and had built a house-boat, in which the machine could not only be stored, but which would also furnish space for workshops, and on the top of which was mounted a turntable and track for use in launching from whatever direction the wind might come.

Everything connected with the work was expedited as much as possible with the expectation of being able to have the first trial flight before the close of 1899, and time and money had been spent on the aerodrome, which was ready, except for its engine, when the time for the delivery of this arrived. But now the builder proved unable to complete his contract, and, after months of delay, it was necessary to decrease the force at work on the machine proper and its launching appliances until some assurance could be had of the final success of the engine. During the spring and summer of 1899, while these delays were being experienced in procuring suitable engines, former experiments on superposed wing surfaces were continued, time was found for overhauling the two steam-driven models which had been used in 1896, and the small house boat was rebuilt so that further tests of these small machines might be made in order to study the effect of various changes in the balancing and the steering, equilibrium preserving and sustaining appliances, and the months of June, July and a portion of August were spent in actual tests of these machines in free flight.

A new launching apparatus following the general plan of the former overhead one, but with the track underneath it, was built for the models, and it was used most successfully in these experiments, more than a dozen flights in succession being made with it, while in every case it worked without delay or accident. As soon as these tests with the models on this underneath launching apparatus were completed, that for the large machine was built as an exact duplicate, except for the enlargement, and with some natural confidence that what had worked so perfectly on a small scale would work fairly on a large one.

It was recognized from the very beginning that it would be desirable in a large machine to use "superposed" sustaining surfaces (that is, with one wing above another) on account of their superiority so far as the relation of strength to weight is concerned, and from their independence of guy wiring; and two sets of superposed sustaining surfaces of different patterns were built and experimented with in the early tests. These surfaces proved, on the whole, inferior in lifting power, though among compensating advantages are the strength of a "bridge" construction which dispenses with guy wires coming up from below, which, in fact, later were the cause of disaster in the launching.

It was finally decided to follow what experiment had shown to be successful, and to construct the sustaining surfaces for the large machine after the "single-tier" plan. This proved to be no easy task, since in the construction of the surfaces for the small machines the main and cross ribs of the framework had been made solid, and, after steaming, bent and dried to the proper curvature, while it was

obvious that this plan could not be followed in the large surfaces on account of the necessity, already alluded to, of making them relatively lighter than the small ones, which were already very light. After the most painstaking construction, and tests of various sizes and thicknesses of hollow square, hollow round, I-beam, channel, and many other types of ribs, I finally devised a type which consisted of a hollow box form, having its sides of tapering thickness, with the thickest part at the point midway between contiguous sides and with small partitions placed inside every few inches in somewhat the same way that nature places them in the bamboo. These various parts of the rib (corresponding to the quill in a wing) were then glued and clamped together, and after drying were reduced to the proper dimensions and the ribs covered with several coats of a special marine varnish, which it had been found protected the glued joints from softening, even when they were immersed in water for twenty-four hours.

Comparative measurements were made between these large cross ribs, 11 feet long, and a large quill from the wing of a harpy eagle, which is probably one of the greatest wonders that nature has produced in the way of strength for weight. These measurements showed that the large, 11-foot ribs ("quills") for the sustaining surfaces of the large machine were equally as strong, weight for weight, as the quill of the eagle; but much time was consumed in various constructions and tests before such a result was finally obtained.

During this time a model of the large machine, one fourth of its linear dimensions, was constructed, and a second contract was made for an engine for it. The delay with the large engine was repeated with the small one, and in the spring of 1900 it was found that both contract engines were failures for the purpose for which they were intended, as neither one developed half of the power required for the allotted weight.

I accordingly again searched all over this country, and, finally, accompanied by an engineer (Mr. Manly), whose services I had engaged, went to Europe, and there personally visited large builders of engines for automobiles, and attempted to get them to undertake the construction of such an engine as was required. This search, however, was fruitless, as all of the foreign builders, as well as those of this country, believed it impossible to construct an engine of the necessary power and as light as I required (less than 10 pounds to the horsepower without fuel or water). I was, therefore, forced to return to this country and to consent most reluctantly, even at this late date, to have the work of constructing suitable engines undertaken in the shops of the Smithsonian Institution, since, as I have explained, the aerodrome frame and wings were already constructed. This work

upon the engines began here in August, 1900, in the immediate care of Mr. Manly. These engines were to be of nearly double the power first estimated and of little more weight, but this increased power and the strain caused by it demanded a renewal of the frame as first built, in a stronger and consequently in a heavier form, and the following sixteen months were spent in such a reconstruction simultaneously with the work on the engines.

The flying weight of the machine complete, with that of the aeronaut, was 830 pounds; its sustaining surface, 1,040 square feet. It, therefore, was provided with slightly greater sustaining surface and materially greater relative horsepower than the model subsequently described which flew successfully. The brake horsepower of the engine was 52; the engine itself, without cooling water, or fuel, weighed approximately 1 kilogram to the horsepower. The entire power plant, including cooling water, carburetor, battery, etc., weighed materially less than 5 pounds to the horsepower. Engines for both the large machine and the quarter-size model were completed before the close of 1901, and they were immediately put in their respective frames and tests of them and their power-transmission appliances were begun.

It is well here to call attention to the fact that although an engine may develop sufficent power for the allotted weight, yet it is not at all certain that it will be suitable for use on a machine which is necessarily as light as one for traversing the air, for it would be impossible to use, for instance, a single cylinder gasoline engine in a flying machine unless it had connected to it prohibitively heavy flywheels. These facts being recognized, the engines built in the Smithsonian shops were provided with five cylinders, and it was found upon test that the turning effect received from them was most uniform, and that, by suitable balancing of rotating and reciprocating parts, they could be made to work so that there was practically no vibration, even when used in the very light frames of the aerodromes.

The engine is not all the apparatus connected with the development and delivery of power, for obviously there must be shafts, bearings, and in the present case there were also gars; and all of these parts must necessarily be phenomenally light, while all of the materials must be capable of withstanding repeated and constant strains far beyond their elastic limit. It is also evident to any one having familiarity with such constructions that it is most difficult to keep the various bearings, shafts, gears, etc., in proper alignment without adding excessive weight, and also that when these various parts once get out of alignment when subject to strain, the disasters which are caused render them unfit for further use.

The engines themselves were successfully completed before the close

of 1901, and were of much more power than those originally designed; but nearly a year and a half had been spent not only in their completion, but in properly coordinating the various parts of the frame carrying them, repairing the various breakages, assembling, dismounting and reassembling the various parts of the appliances, and in general rebuilding the frame and appurtenances to correspond in strength to the new engines.

There are innumerable other details, for the whole question is one of details. I may, however, particularly mention the carburetors, which form an essential part of every gas engine, and such giving fair satisfaction for use in automobiles were on the market at the time, yet all of them failed to properly generate gas when used in the tests of the engine working in the aerodrome frame, chiefly because of the fact that the movement of the engine in this light frame must be constant and regular or the transmission appliances are certain of distortion. It was, therefore, necessary to devise carburetors for the aerodrome engines which would meet the required conditions, and more than half a dozen were constructed which were in advance of anything then on the market, and yet were not good enough to use in the aerodrome, before a satisfactory one was made. These experiments were made in the shop, but with an imitation of all the disturbing influences which would be met with in the actual use of the machine in the air, so as to make certain, as far as possible, that the first test of the machine in free flight would not be marred by mishaps or unseen contingencies in connection with the generation and use of power.

It is impossible for any one who has not had experience with such matters to appreciate the great amount of delay which experience has shown is to be expected in such experiments. Only in the spring of 1903, and after two unforeseen years of assiduous labor, were these new engines and their appurtenances, weighing altogether less than 5 pounds to the horsepower and far lighter than any known to be then existing, so coordinated and adjusted that successive shop tests could be made without causing injury to the frame, its bearings, shafts or propellers.

And now everything seemed to be as nearly ready for an experiment as could be, until the aerodrome was at the location at which the experiments were to take place. The large machine and its quarter-size counterpart were accordingly placed on board the large house boat, which had been completed some time before and had been kept in Washington as an auxiliary shop for use in the construction work, and the whole outfit was towed to a point in the Potomac River, here three miles wide, directly opposite Widewater, Va., and about forty miles below Washington and midway between the Maryland and Virginia

shores, where the boat was made fast to moorings which had previously been placed in readiness for it

Although extreme delays had already occurred, yet they were not so trying as the ones which began immediately after the work was thus transferred to the lower Potomac.

The object in constructing the quarter-size counterpart of the large machine was to duplicate in it the balancing and relative proportions of power, surface, etc., that had been arranged in the large one, so that a test of it might be made which would determine whether the large machine should be tried as arranged or the balancing and other arrangements modified. The launching apparatus, which had proved so eminently successful with the original steam-driven models in 1896, was considered a thing so well tested that it had, as I have stated, been duplicated on a suitable scale for use with the large aerodrome, and it was felt that if this apparatus were exactly similar to the smaller one it would be the one appliance least likely to mar the experiments.

In order to test the quarter-size model it was necessary to remove its launching track from the top of the small house boat and place it upon the deck of the large boat, in order to have all the work go on at one place, as it was impossible, on account of its unseaworthiness, to moor the small house boat in the middle of the river.

While this transfer of the launching apparatus from the small boat to the large one was being made, the changed atmospheric conditions incident to a large body of water over which thick fogs hung a great portion of the time, from those of a well-protected shop on the land, began to manifest themselves in such ways as the rusting of the metal parts and fittings, and the consequent disarrangement of the adjustment of the necessarily very accurate pieces of apparatus connected with the ignition system of the engine. These difficulties might have partly been anticipated, but there were others concerning which the cause of the deterioration and disarrangement of certain parts and adjustments was not immediately detected, and consequently when short preliminary shop tests of the small machine were attempted just prior to launching it, it was found that the apparatus did not work properly, necessitating repairs and new constructions and consequent delay. Although the large house boat with the entire outfit had been moved down the river on July 14, 1903, it was not until the eighth of August that the test of the quarter-size model was made, and all of this delay was directly due to changed atmospheric conditions incident to the change in locality. This test of the model in actual flight was made on the eighth of August, 1903, when it worked most satisfactorily, the launching apparatus, as always heretofore, performing perfectly, while the model, being launched directly into the face of the wind, flew directly ahead on an even keel. The balancing

proved to be perfect, and the power, supporting surface, guiding and equilibrium-preserving effects of the rudder also. The weight of the model was 58 pounds, its sustaining surface 66 square feet, and the horsepower from 2½ to 3.

This was the first time in history, so far as I know, that a successful flight of a mechanically sustained flying machine was made in public.

The flight was not as long as had been expected, as it was found afterwards that one of the workmen, in his zeal to insure an especially good one, had overfilled the gasoline tank, which would otherwise have enabled a flight several times as long. However, as such a flight would have given absolutely no more data than the short one did, and as the delays in getting ready for testing the large machine had already far exceeded what was expected, it was thought best not to make any more tests with the small one, as all of the data which were desired had been procured, and it was accordingly stored away and every energy immediately concentrated in getting the large machine ready for its first test, which at that time seemed only a few days away.

During all these delays it may be remarked that we necessarily resided near the house boat, and therefore in a region of malaria, from whose attacks a portion of us suffered.

I have spoken of the serious delays in the test of the small machine caused by changed atmospheric conditions, but they proved to be almost negligible compared with what was later experienced with the large one. I have also alluded to the fact that the necessarily light ribs of the large sustaining wing surfaces were covered with several coats of a special marine varnish which many tests had shown enabled the glue to withstand submersion in water for more than twenty-four hours without being affected. This water test was made with a view to guarding against the joints of the ribs being softened when the machine came down into the water, as it was planned for it to do at the close of its flight, and these submersions had apparently shown that no trouble need be anticipated from the effects of the sustaining surfaces getting wet. It is an instance of the unpredictable delays which present themselves, that when preparations had been begun for the immediate trial of the large machine, already down the river, it was found that every one of the cross ribs had been rendered almost useless by the damp, though under shelter. As it would take months to build new ones, a temporary means of repairing them was used. There were other delays too numerous to mention, but chiefly incident to working over the water, some of the principal of which were due to storms dragging the house boat from its moorings and destroying auxiliary apparatus, such as launches, boats, rafts, etc., to say nothing of the time consumed in bringing workmen to and from the scene of

the experiments. The propellers were even found to break under the strain of the actual engines in the open, though they had not done so in the shop, and this is mentioned as another instance of the numerous causes of trying delay which it was impossible to foresee.

Finally, however, on the 3d of September, everything seemed to be in readiness for the experiments, and the large aerodrome was accordingly placed in position and all orders given and arrangements made for a test that day. After stationing the various tugs, launches, etc., at their predetermined positions so that they might render any assistance necessary to the engineer or the aerodrome, in case it came down in the water at a point distant from the house boat, and after the photographers, with special telephoto cameras, had been stationed on the shore in order that photographs with their trigonometrical data might be obtained, from which speed, distance, etc., might be later determined, and when every one was anxiously expecting the experiment, a delay occurred from one of the hardly predictable causes just mentioned in connection with the weather. An attempt was made to start the engine so that it might be running at its proper rate when the aerodrome was launched into free air after leaving the track, but the dry batteries used for sparking the engine, together with the entire lot of several dozen which were on hand as a reserve, had become useless from the dampness.

I have merely instanced some of these causes of failure when everything was apparently ready for the expected test, but only one who was on the spot and who had interest in the outcome could appreciate trials of this sort, and the delays of waiting for weather suitable for experiments.

It was found that every storm which came anywhere in the vicinity, immediately selected the river as its route of travel, and although a ten-mile wind on the land would not be an insurmountable obstacle during an experiment, yet the same wind on the river rendered it impossible to maintain the large house boat on an even keel and free from pitching and tossing long enough to make a test.

While speaking of the difficulties imposed by the weather, it should also be understood that to take the aerodrome in parts from under the shelter of the roof and assemble and mount it upon the upper works was a task requiring four or five hours, and that during this time a change in the weather was altogether likely to occur, and did repeatedly occur, sufficient to render the experiment impossible. Experience has shown, then, that the aerodrome should be sheltered by a building, in which it shall be at all times ready for immediate launching. During all the delay resulting from this and other causes—since it was never known on what day the experiment might take place—a great expense for tug boats waiting at a distance of forty miles from

the city, was incurred, and this was a part of the continuous drain on the pecuniary resources, which proved ultimately more fatal than any mishap to the apparatus itself.

Following the 3d of September, and after procuring new batteries, short preliminary tests inside the boat were made in order to make sure that there would be no difficulty in the running of the engine the next time a fair opportunity arrived for making a test of the machine in free flight. Something of the same troubles which had

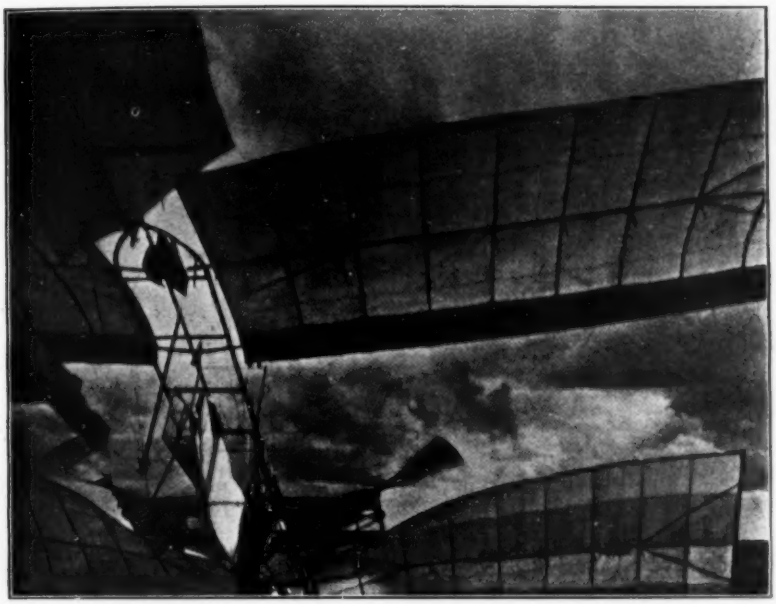

FIG. 1. INSTANTANEOUS PHOTOGRAPH OF THE LAUNCH OF OCTOBER 7, 1903.

been met with in the disarrangement of the adjustments of the small engine was experienced in the large one, although they occurred in such a different way that they were not detected until they had caused damage in the tests, and these disarrangements were responsible for broken propellers, twisted shafts, crushed bearings, distorted framework, etc., which were not finally overcome until the first of October. After again getting everything in apparent readiness, there then ensued a period of waiting on the weather until the seventh of October (1903), when it became sufficiently quiet for a test, which I was now beginning to fear could not be made before the following season. In this, the first test, the engineer took his seat, the engine started with ease and was working without vibration at its full power of over fifty horse, and the word being given to launch the machine, the car was released and the aerodrome sped along the track. Just as the machine left the track, those who were watching it, among whom

were two representatives of the Board of Ordnance,[2] noticed that the machine was jerked violently down at the front (being caught, as it subsequently appeared, by the falling ways),[3] and under the full power of its engine was pulled into the water, carrying with it its engineer. When the aerodrome rose to the surface it was found that, while the front sustaining surfaces had been broken by their impact with the water, yet the rear ones were comparatively uninjured. As soon as a full examination of the launching mechanism had been made, it was found that the front portion of the machine had caught on the launching car, and that the guy post, to which were fastened the guy wires which are the main strength of the front surfaces, had been bent to a fatal extent.

The machine, then, had never been free in the air, but had been pulled down as stated.

The disaster just briefly described had indefinitely postponed the test, but this was not all. As has been said before, the weather had become very cold, and the so-called equinoctial storms being near, it was decided to remove the house boat at the earliest time possible, but before it could be done a storm came up and swept away all the launches, boats, rafts, etc., and in doing so completely demolished the greater part of them, so that when the house boat was finally removed to Washington, on the fifteenth of October, these appurtenances had to be replaced. It is necessary to remember that these long series of delays worked other than mere scientific difficulties, for a more important and more vital one was the exhaustion of the financial means for the work.

Immediately upon getting the boat to Washington the labor of constructing new sustaining surfaces was begun, and they were completed about the close of November. It was proposed to make a second attempt near the city, though in the meantime the ice had formed in the river. However, on the eighth of December, 1903, the atmosphere became very quiet shortly before noon and an immediate attempt was made at Arsenal Point, quite near Washington, though the site was unfavorable. Shortly after arriving at the selected point everything

[2] Major Macomb, of the Board of Ordnance, states in his report to the board, that "the trial was unsuccessful because the front guy post caught in its support on the launching car and was not released in time to give free flight, as was intended, but, on the contrary, caused the front of the machine to be dragged downward, bending the guy post and making the machine plunge into the water about 50 yards in front of the house boat."

[3] This instantaneous photograph, taken from the boat itself and hitherto unpublished, shows the aerodrome in motion before it had actually cleared the house boat. On the left is seen a portion of a beam, being a part of the falling ways in which the front wing was caught, while the front wing itself is seen twisted, showing that the accident was in progress before the aerodrome was free to fly.

was in readiness for the test. In the meantime the wind had arisen and darkness was fast approaching, but as the funds for continuing the work were exhausted, rendering it impossible to wait until spring for more suitable weather for making a test, it was decided to go on with it if possible This time there were on hand to witness the test the writer, members of the Board of Ordnance, and a few other guests, to say nothing of the hundreds of spectators who were waiting on the various wharves and shores. It was found impossible to moor the boat without a delay which would mean that no test could be made on account of darkness, so that it was held as well as possible by a tug, and kept with the aerodrome pointing directly into the wind, though the tide, which was running very strong, and the wind, which was blowing ten miles an hour, were together causing much difficulty. The engine being started and working most satisfactorily, the order was given by the engineer to release the machine, but just as it was leaving the track another disaster, again due to the launching ways, occurred.[4] This time the rear of the machine, in some way still unexplained, was caught by a portion of the launching car, which caused the rear sustaining surfaces to break, leaving the rear entirely without support, and it came down almost vertically into the water. Darkness had come before the engineer, who had been in extreme danger, could aid in the recovery of the aerodrome, the boat and machine had drifted apart, and one of the tugs, in its zeal to render assistance, had fastened a rope to the frame of the machine in the reverse position from what it should have been attached and had broken the frame entirely in two. While the injury which had thus been caused seemed almost irreparable to one not acquainted with the work, yet it was found upon close examination that only a small amount of labor would be necessary in order to repair the frame, the engine itself being entirely uninjured. Had this accident occurred at an earlier period, when there were funds available for continuing the experiments, it would not have been so serious, for many accidents in shop tests had occurred which, while unknown to the general public, had yet caused greater damage and required more time for repair than in the present case. But the funds for continuing the work were exhausted, and it being found impossible to immediately secure others for continuing it, it was found necessary to discontinue the experiments for the present, though I decided to use, from a private fund, the small amount of money

[4] Major Macomb again states in his official report to the board: "The launching car was released at 4:45 P.M. . . . The car was set in motion and the propellers revolved rapidly, the engine working perfectly, but there was something wrong with the launching. The rear guy post seemed to drag, bringing the rudder down on the launching ways, and a crashing, rending sound, followed by the collapse of the rear wings, showed that the machine had been wrecked in the launching; just how it was impossible to see."

necessary to repair the frame so that it itself, together with its engine, which was entirely uninjured, might be available for further use if it should later prove possible, and that they themselves might be in proper condition to attest to what they really represent as an engineering achievement.

Entirely erroneous impressions have been given by the account of these experiments in the public press, from which they have been judged, even by experts; the impression being that the machine could not sustain itself in flight. It seems proper, then, to emphasize and to reiterate, with a view to what has just been said, that the machine has never had a chance to fly at all, but that the failure occurred on its launching ways; and the question of its ability to fly is consequently, as yet, an untried one.

There have, then, been no failures as far as the actual test of the flying capacity of the machine is concerned, for it has never been free in the air at all. The failure of the financial means for continuing these expensive experiments has left the question of their result where it stood before they were undertaken, except that it has been demonstrated that engines can be built, as they have been, of little over one half the weight that was assigned as the possible minimum by the best builders of France and Germany; that the frame can be made strong enough to carry these engines, and that, so far as any possible prevision can extend, another flight would be successful if the launching were successful; for in this, and in this alone, as far as is known, all the trouble has come.

The experiments have also given necessary information about this launching. They have shown that the method which succeeded perfectly on a smaller scale is insufficient on a larger one, and they have indicated that it is desirable that the launching should take place nearer the surface of the water, either from a track upon the shore or from a house boat large enough to enable the apparatus to be launched at any time with the wings extended and perhaps with wings independent of support from guys. But the construction of this new launching apparatus would involve further considerable expenditures that there are no present means to meet; and this, and this alone, is the cause of their apparent failure.

Failure in the aerodrome itself or its engines there has been none; and it is believed that it is at the moment of success, and when the engineering problems have been solved, that a lack of means has prevented a continuance of the work.

THE PROGRESS OF SCIENCE

THE FIFTIETH ANNIVERSARY OF THE ANNOUNCEMENT OF THE THEORY OF NATURAL SELECTION

MODERN biological science may be said to date from the presentation by Charles Darwin and Alfred Russel Wallace to the Linnean Society on July 1, 1858, of the theory of the origin of species by means of natural selection. The title of the joint paper was "On the Tendency of Species to form Varieties and on the Perpetuation of Varieties and Species by Natural Means of Selection." This paper was presented to the society by Joseph D. Hooker and Charles Lyell, and the circumstances of the case are familiar to most readers of this journal.

It will be remembered that Mr. Wallace sent Darwin a paper written at Ternate in the Malay Archipelago in February, 1858, "On the Tendency of Varieties to depart Indefinitely from the Original Type." The argument was strikingly similar to that of a manuscript work on species which Darwin had sketched in 1839 and copied in 1844, when it was read by Hooker and its contents subsequently communicated to Lyell. During all this time Darwin had been accumulating facts and weighing objections to the theory. It was his first intention to allow Wallace's paper to be printed without his own, but he was persuaded by Hooker and Lyell to assent to a joint presentation of his sketch, together with a letter to Asa Gray dated September 5, 1857, and the paper by Wallace before the Linnean Society. With an introduction by Lyell and Hooker, it was read by the secretary to the society in July, 1858, and published that year in its journal. The papers were reprinted in the issue of THE POPULAR SCIENCE MONTHLY for November, 1901.

The fiftieth anniversary of this event has now been adequately celebrated by the Linnean Society. It was of special interest that Dr. Wallace and Sir Joseph Hooker were present and made addresses. With the admirable generosity which has always characterized the relations of the two men, Wallace yielded the superior part to Darwin. He pointed out a certain similarity in their careers—both had been collectors

THE DARWIN-WALLACE MEDAL OF THE LINNEAN SOCIETY.

A sketch from life by V. Monkhouse published in Knowledge.

DR. FRANCIS DARWIN,
President of the Dublin Meeting of the British Association.

in early life, both had traveled extensively, and both had at the critical moment read Malthus's "Essay on Population." Darwin himself, however, has pointed out that they differed in so far as he was led to his views from a consideration of what artificial selection has done for domestic animals. Sir Joseph Hooker described the events preceding and at the time of the presentation of the paper, from which Darwin was absent through illness. A medal struck by the society—here reproduced by the courtesy of his secretary—was presented in gold to Dr. Wallace and in silver to Sir Joseph Hooker, Professor Ernst Haeckel, Professor Eduard Strasburger, Professor August Weismann, Dr. Francis Galton and Sir E. Ray Lankester. Responses were made by Professor Strasburger, Dr. Galton and Sir E. Ray Lankester, and by delegates from universities and academies, including Dr. Francis Darwin and Lord Avebury.

The hundredth anniversary of the birth of Darwin will occur on February 12 of next year, which is also the hundredth anniversary of the birth of Lincoln. The event will be celebrated by the University of Cambridge, and in this country by Columbia University and the New York Academy of Sciences and doubtless elsewhere. The American Association for the Advancement of Science will, at its Baltimore meeting, give special prominence to exercises in honor of the hundredth anniversary of Darwin's birth and the fiftieth anniversary of the publication of "The Origin of Species."

THE DUBLIN MEETING OF THE BRITISH ASSOCIATION

THE recent meeting of the British Association had a program of the usual high standard and an attendance of 2,270 members and associates. The size of the meeting was about the same as the larger convocation-week meetings of the American Association and its affiliated societies, but the number of scientific men and of scientific papers is greater in this country. There were at Dublin 1,374 associates, mainly people living in Dublin and vicinity, who joined the association for the meeting, though not especially interested in science. The American Association has not been able to attract to its meetings people of this class. This is doubtless in part due to better social organization in Great Britain—the sentiment which leads the London *Times* to devote pages to reports of the meeting and every country house to take in *Nature*—but it is also in part due to the fact that the meetings are made more attractive to those not professionally engaged in scientific research. It seems that our association should aim to do more for this class, for from it science needs sympathy, support and recruits.

Mr. Francis Darwin, the president of the meeting, who, like his brother, Sir George Darwin, the president of the South African meeting three years ago, bears worthily his great name now being celebrated on the occasion of the fiftieth anniversary of the publication of the "Origin of Species," chose as the subject of his inaugural address the reactions of plants. His own experimental work has been largely in this field, and the address was made interesting to a large audience by a discussion of consciousness in plants and the hereditary transmission of acquired characters. Public lectures were given by Professor H. H. Turner, of Oxford, on "Halley's Comet" and by Professor W. M. Davis, of Harvard University, on "The Lessons of the Colorado Cañon." The annual lecture to the working classes was by Dr. A. E. Tutton, on "The Crystallization of Water."

The entertainments and excursions were as usual very elaborate. The reception given by the Royal Dublin Society was attended by 4,000 guests, and there were numerous luncheons

DR. J. J. THOMSON,
Cavendish Professor of Experimental Physics at Cambridge University,
President of the Winnipeg Meeting of the British Association.

and garden parties. Special services were held in the Episcopalian, Presbyterian and Roman Catholic churches, and the University of Dublin conferred honorary degrees on a number of the distinguished visitors.

The large annual membership of the association and the comparatively large fee enable it to make liberal grants for scientific research, amounting this year to about $7,000. Among the grants of $250 or more were the following: Professor H. H. Turner, for seismological observations; Sir David Gill, towards building a solar observatory in Australia; Sir W. H. Preece, for the study of gaseous explosions; Professor J. Joly, for geological investigations at Briske, and Mr. D. G. Hogarth, for archeological explorations in Crete.

Dr. J. J. Thomson, Cavendish professor of experimental physics at Cambridge and eminent for his research work concerned with the X-rays, radium and the breaking up of the atom, was elected president for the meeting to be held next year at Winnipeg, beginning on August 25. Members of the American Association are invited to attend this meeting, and those who are able to be present are certain to enjoy unusual pleasure and profit.

THE PRESENT PANDEMIC OF PLAGUE

THE bulletin with this title prepared by Assistant Surgeon General, J. M. Eager, and issued by the Public Health and Marine Hospital Service, exhibits in a bald way the relentless forward march of the bubonic plague, a circumstance more terrible and dramatic perhaps than anything else in contemporary history. Emerging from the obscure endemic focus in the province of Yunnan, China, in the year 1894, the plague appeared in Canton, and there were a hundred thousand deaths between March and August. The disease spread to Hong Kong and in 1896 to Bombay, there being some two thousand deaths in the presidency. In 1897 there were over 55,000 deaths in India, including nearly 10,000 in the city of Bombay, with sporadic cases in Japan and Turkey. In 1898 there were 117,000 deaths in India, and extending far from its endemic home, there were cases in Madagascar and Mauritius. In 1899 there were 135,000 deaths in India and serious epidemics in China. Cases occurred in Egypt and the Hawaiian Islands, and South America was invaded. There were local epidemics in Portugal and Russia. In 1900 there was a diminution in India, the deaths falling to 92,000, but the disease invaded San Francisco and was present, and remains present, in every quarter of the world, Europe, Asia, Africa, Oceanica, North and South America. In 1901 the hope of relief in India was disappointed, the deaths rising to 278,000, and in 1902 to 575,000. They increased further to 835,000 in 1903, and to the neighborhood of one million in 1904 and 1905, falling in 1906 to 332,000, but rising again last year to the appalling record of 1,400,000 cases and 1,200,000 deaths. The plague was present in all quarters of the world, there being 156 cases and 76 deaths in San Francisco, and cases in the suburbs and in Seattle.

If it were not for the great advance of modern medicine western civilization would be threatened with a disaster unparalleled since the middle ages. But the means by which the plague is transmitted have been discovered—we can exterminate fleas and rats if necessary—and, thanks to the labors of scientific and medical men, not a few of whom have sacrificed their lives, we are comparatively secure. But protective measures and more knowledge are needed here and in many directions, and the governments of the world should spend not less care and money on them than on their armaments.

SCIENTIFIC ITEMS

WE record with regret the deaths of Dr. Charles Harrington, professor of hygiene in the Harvard Medical School and chairman of the Massachusetts State Board of Health; of the Earl of Rosse, F.R.S., who, like his father, made valuable contributions to astronomy; of M. E. Mascart, since 1871 director of the French Meteorological Office, and of General J. F. Nery Delgado, for many years director of the Geological Survey of Portugal.

THE Academy of Sciences at Turin has awarded its Riberi prize of the value of $4,000 to Professor Bosio, of Turin, for his discoveries in relation to the biological reactions to arsenic, tellurium and selenium.—The British Ornithologists' Union will celebrate its fiftieth anniversary in December next, when gold medals will be presented to the four surviving original members: Dr. F. Du Cane Godman, F.R.S., Mr. P. S. Godman, Mr. W. H. Hudleston, F.R.S., and Dr. P. L. Sclater, F.R.S.

PROFESSOR L. H. BAILEY has been given leave of absence from the directorship of the College of Agriculture of Cornell University to devote his time to the chairmanship of the commission appointed by President Roosevelt to investigate the conditions of rural life. The other members of the commission are: Henry Wallace, of *Wallace's Farmer*, Des Moines, Ia.; President Kenyon L. Butterfield, of the Massachusetts Agricultural College; Gifford Pinchot, chief of the Forest Service, and Walter H. Page, editor of the *World's Work*.—Dr. Charles H. Judd, professor of psychology at Yale University, has been elected dean of the school of education and head professor of the department of education at the University of Chicago, the appointment to take effect at the close of the present academic year.

THE Berlin Academy of Sciences has received a legacy of $7,500,000 from Herr Samson, a banker of that city. —M. Henri Becquerel has bequeathed $20,000 to the Paris Academy of Sciences in memory of his grandfather and his father, who were members of the academy.